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Recognition and acknowledgement: A consideration of the limits to the idea of "early warning"

Preliminary remarks

The German Federal Minister of Research and Technology divides his work on technology assessment (TA) into four areas: Early detection, impact and precautionary research, specific technology assessment analyses, and infrastructure and international cooperation (BMFT 1987, p. 11). A series of national research, such as the project group at the Gesellschaft für Strahlen- und Umweltforschung (Society for Radiation and Environmental Research), which started in 1985 and continued with ecosystem monitoring programs and the development of bioprobes (BMFT 1989, p. 7ff.), also served the early detection of environmental problems in particular. The concept or concern of "early warning" (as it used to be called) is the subject of the following considerations. The focus is not only on early detection as such, but also on its cognitive, normative, and procedural problems, as they arise analogously in the concept of technology assessment in its function as an "early warning system," as an instrument for *timely* detection and assessment.

1. State action and early warning

With the emergence of large-scale technologies as part of the industrial modernization process, the state has increasingly become the driving force and subject of scientific and technological development. Without state planning and decisions, without the pre-financing of research work, the covering of risks, and without the expansion of the economic infrastructure, the development of nuclear technology, for example, would likely not have come about (Keck 1984; Radkau 1989). The technical infrastructure systems in transportation and communication are also often actively built and operated by the state (Mayntz/Hughes 1988). At the same time, however, the state has also assumed responsibility for the associated risks and dangers (Murswiek 1988).

One consequence of this development is the increasing politicization of scientific and technological development. Decisions that used to be made by individual entrepreneurs and scientists have in many cases become political decisions, so that responsibility for the consequences of technological innovations, in particular for their technical and social disruptive potential, is also attributed to the political system. Due to the confrontation with the undesirable consequences and global risks associated with the introduction of new technologies, political action today operates in a field of social debate in which its legitimacy is called into question. In fact, there have been fierce social debates in the field of technology policy in recent years. These have contributed to the dissolution of the population's positive basic consensus with regard to technological progress and have caused a significant loss of legitimacy for politics.

There are many reasons for the politicization of technological development and the fragmentation of the basic social consensus on the future directions of development of industrial society. Factors of social change also play a role here, which are only conditionally related to technical-scientific development, such as an emerging new value consciousness (Klages 1988). It is certain that a major reason for the loss of legitimacy of politics can be seen in its interplay with scientific and technological development, which is difficult for the general public to understand. The use of science and technology increases the interdependence and consequences of decisions and changes to such an extent that it is difficult to grasp all of their future effects. Examples of this are the safety problems at nuclear power plants and chemical production facilities, the impact on the climate, the problems of determining tolerance thresholds in ecological systems, or the consequences of genetic research and genetic engineering. In all these cases, experiments are being conducted with technical possibilities whose exact consequences no one can determine, but for which politicians must develop a solid basis for decision-making and evaluation.

To the extent that research and technology policy becomes a central component of state activity (OECD 1985, p. 68; cf. Hilpert 1989), state action is faced with a dilemma. The task of creating framework conditions for long-term economic and technological growth tends to conflict with the state's task of averting and preventing danger. From the perspective of constitutional law, it has occasionally been lamented that the original and indispensable state task of averting danger is "in retreat" compared to the "performance and control functions" of the modern state (Martens 1982, p. 29).

While the structural policy task involves, among other things, promoting technologies to application maturity that are not developed by the private sector either for cost reasons or because of the high risks involved, the task of hazard prevention involves eliminating existing hazards and preventing future ones.

The political-administrative system thus takes on a dual role. On the one hand, it has become an essential initiator of technological progress; on the other hand, it is supposed to take precautions against the risks and possible negative consequences of the very technologies it promotes (Saladin 1984).

This situation is also reflected in national research policy. In the German federal research report 1984 (Bundesforschungsbericht), for example, the general objectives of research and technology policy included not only the promotion of scientific knowledge and technical innovation but also the conservation of resources and the environment, as well as the improvement of living and working conditions (BMFT 1984, p. 14). In this report, the German Federal Government states that it sees "the opportunities of technological development in conjunction with the risks." It must succeed in "exploiting the opportunities offered by technology and reducing possible disadvantages to the lowest possible and at least acceptable level in an orderly process of risk assessment, political opinion-forming and decision-making" (BMFT 1984, p. 18).

In order to achieve these goals, the German Federal Government relies, among other things, on "systematic technology impact and potential assessment" and "early warning" (BMFT 1984, ibid.). In its report "Status und Perspektiven der Großforschungseinrichtungen" [Status and perspectives of large research institutions], it goes into more detail on the aspect of early warning. There it reaffirms its intention to build up an "early warning network" for the early identification of potential danger areas and risks (but also technological opportunities) by drawing on the scientific and technical potential of large research facilities in order to be able to take appropriate measures in good time (Bundesregierung 1984a, p. 30). In the meantime, appropriate steps have also been taken to coordinate existing knowledge toward such an objective and to develop new types of scientific observation instruments (BMFT 1987, p. 15; BMFT 1990, p. 5ff.).

The formula of "early detection of technology-related dangers and risks" is to a certain extent the link in the centrifugal movement of the diverging roles of the state administration: Technology is to be massively promoted, but at the same time the problems, side effects, and long-term consequences of these promoted technological developments are to be recognized in good time in order to limit or completely avoid the corresponding risks.

However, containment and avoidance require the will of the political administration to abandon developments if necessary, or at least to modify them and promote alternative technologies.

If one analyzes the term "early recognition," it has two components of meaning: A cognitive one (*early recognition* of problems) and a normative one (*timely recognition* of developing problems that call for political action). Although mixed in the specific case, the analytical distinction between these two functions of early recognition – which can also be applied to TA – is helpful: On the one hand, it is a problem of knowledge, of stimulating research, of more precise or even just more sensitive observation, of discovering connections; but on the other hand, it is a problem of recognizing problem situations, i.e., of accepting that action must be taken without the respective problem situation having already developed into an irrefutable political and social problem.

From a *cognitive point of view*, early detection implies that its task cannot be limited to the identification of already emerging individual risk areas or suspicious toxic substances. The singular risk, the monocausal analysis of cause-and-effect chains cannot be its primary object, even if it absolutely must be based on the relevant research that has already been carried out.

The specificity of early detection obviously lies in those dangers and risks that have a "systematic" quality in terms of their causes and/or effects.

In terms of the constellation of causes, these are dangers that can arise from the exposure of ecological systems to small quantities of substances that were previously considered harmless (the "sleepers" so to speak, among the consequences of technology), or synergistic effects that have not been researched. In terms of the effects, we are talking about potential damage to (interdependent) systems (biotopes, political systems, social structures) that do not occur as a result of a single factor.

It follows, as will be shown, that normative aspects (e.g., selection and relevance criteria) are incorporated into the organization of the cognitive process of early detection at each stage (problem identification, problem conceptualization, information selection and analysis, interpretation, and result evaluation).

From a *normative point of view*, early detection implies that hazards and risks are identified and qualified early enough to define "alternative courses of action" and prepare "decision-making" (BMFT 1984, p. 30), which leads to their containment and prevention. Since – as mentioned – relevant research activities (including long-term forecasts) already exist, a key political and institutional aspect is obviously to coordinate existing and, if necessary, newly created capacities in the field of technology research with the explicit objective of "early warning" and to orient them toward scientific policy advice.

However, this raises a specific political problem. Early or timely recognition of technology-related dangers and risks also means that it takes place at a time when these dangers have not yet manifested themselves, i.e., they have not yet created an immediate need for political action. Where possible, prophylaxis should replace therapy.

In view of the cognitive, political, and institutional characteristics of early warning, however, it is obvious that this form of scientific policy advice is less able to replace political decisions and actions than other forms. Early warning will – as has been and continues to be the case with TA – be scientifically and politically controversial. The new demands it places on science and politics will be analyzed in the next two sections.

2. Possibilities and limits of scientific methods for early warning

The German Federal Government's 1984 report on the status and perspectives of large research institutions, in which the intention to set up an "early warning network" is stated, gives the impression that the primary aim is to align, reorganize, and restructure existing knowledge and scientific infrastructure toward the goal of "early warning" (Bundesregierung 1984a, p. 30f.).

Although the diagnosis and prognosis of technology-related risks to humans and the environment cannot be the sole task of individual scientific disciplines and is therefore already the subject of wide-ranging research in the economic and social sciences, as well as in the field of practically-oriented project research (risk and safety research, environmental impact research, systems analysis, and technology assessment), the impression is that it is the "exact" natural sciences in particular that are expected to provide the most unequivocal findings possible on cause-and-effect relationships in this field. Such "hard" findings are intended to prepare the ground for decision-making.

And there is more: The Bundesforschungsbericht VII [Federal Research Report VII] states that "reliable technical-scientific" statements are the prerequisite for environmental policy action, e.g., statements that "clarify ecological relationships and causal causes/effect chains" (Bundesregierung 1984b, p. 128).

The example of the large-scale experiment at the time of the report on the effects of a speed limit for road traffic on air pollution illustrates this attitude of "acting only after unquestionable scientific knowledge." A more recent example is the German Federal Government's argument that a ban on the use of atrazine is only justifiable if valid and representative results from so-called lysimeter studies are available.

In order to avoid the misunderstanding that politics and the administration alone are being blamed for an overly naïve view of science, it should be clearly stated that the high expectations of science, and the overestimation of its possibilities, are for the most part aroused and nurtured by scientists themselves, and are still often shared today in an equally naïve manner. In our opinion, one of these overestimations is the enduring idea of the possibilities of predicting the development of complex systems.

Current research into the causes of forest dieback and comparable ecological problems clearly shows that the natural sciences are confronted with the interactions between humans and the environment in much the same way as the social and economic sciences are confronted with the complex system interrelationships of their subject areas (Süddeutsche Zeitung, 11.11.1983). These are open systems that are influenced by rare, unpredictable events; systems with non-linear relationships between multiple factors.

Classical natural science often finds it difficult to reach conclusions here because certain standards apply to the recognition of classical scientific work, such as experimental repeatability, proof of causal linkage, statistical proof of significance, freedom from contradiction, and evaluation by the scientific community.

It would also be unrealistic to believe that the consequences of technology can be largely predicted through more intensive scientific research before the technology has even been implemented. In the vast majority of cases, early warning will probably amount to recognizing the emerging consequences before they have taken on an "epidemic" character.

From the temporal aspect – early warning after implementation or prior to implementation – the methodological problems of early warning are to be structured according to two basic approaches:

- problem recognition through the observation of symptoms, i.e., changes compared to the past, which are assigned a "disease value," or which are classified as problematic in some way (Sec. 2.1);
- problem identification by combining and integrating individual knowledge and experience, analogy building, modeling, and simulation to create a forward-looking scenario of the possible effects of one or more technologies (Sec. 2.2).

2.1 Identifying problems by observing symptoms

Damage – e.g., to certain ecosystems or health impairments – is often perceived, the causes of which are unknown at the time of perception and which could not have been causally deduced from the observer's knowledge of the affected system. The problem becomes noticeable through the "conspicuousness of its symptoms," i.e.:

- Changes must already have occurred that are so far advanced that sufficiently conspicuous symptoms become visible.
- There must be an observer who classifies the symptoms as conspicuous, atypical, or pathological.

The symptom-oriented approach is *retrospective* and *analytical* with regard to the identification of risk areas, because it is based on effects that have already occurred, which should be recognized at the earliest possible point in time and analyzed for their causes. Popular examples of problem identification based on symptoms whose causal classification is largely unknown – indeed whose existence is doubted by some scientists in the contexts discussed – are "forest damage," "acidification of lakes," "pseudo-croup," an increase in allergies, or increased mortality during smog episodes.

These examples from the field of ecology illustrate the fundamental problems and possibilities of early detection using a symptom-oriented approach. The case studies are characterized by the following:

- These are relatively cause-unspecific symptoms and phenomena. What is new about the phenomenon of "forest damage," for example, is not necessarily the symptoms themselves, but the possibly novel causes, the frequency, and the spread of their occurrence. The same applies to pseudo-croup and the increase in allergies.
- It is difficult to recognize an epidemic development in good time if the "normal" frequency and the variation in occurrence are not known, especially in the case of cause-unspecific symptoms. One example of this is the so-called "marine bloom," which occurs naturally but is also discussed in connection with marine pollution. This is a short-term explosion in the growth of certain marine algae. Although observations of this phenomenon have been available for a relatively long time and a number of factors for its occurrence are known, there are still so many unknown influences that it is almost impossible to predict when a marine bloom will occur.

- The problems under discussion here are aptly described in the ecological or medical field as complex diseases. This means that many influences and circumstances are involved in the development of the disease, which can often vary from case to case. For example, "itai-itai disease" is most likely not a consequence of high cadmium exposure alone, but must also be caused by poor nutritional status.[1] However, this example also shows that unexpected problems can arise very quickly, for example in connection with certain heavy metal exposures, if influencing factors such as nutritional status etc. change.
- Attempts to clarify the genesis of the observed symptoms often lead to influencing factors, which in turn are very complex and little known (such as the correlation between the input of pollutants into the soil and changes in the microflora and fauna, and thus also certain symbiotic systems of higher plants).
- Statistical investigation methods, primarily correlation analyses (epidemiology), provide indications of potential correlations, but no causal evidence. In the case of air pollutants, for example, several pollutant components correlate with respiratory diseases. To date, it has not been possible to make individual pollutants unequivocally responsible for the observed effects.

However, the role of the observer with regard to early detection should by no means be limited to those with specialist training.

This is particularly true where previously unknown consequences or symptoms are triggered by previously unknown causes. Negative consequences may be perceived more readily by those affected than by experts. However, those affected often do not have the relevant specialist knowledge to be able to go beyond the diffuse feeling that something is conspicuous and not "in order" and provide evidence of actual damage that is recognized by science and politics. However, case studies show that "lay judgement about technical hazards reveal a sensibility to social and political values that experts' models would not acknowledge" (Fiorino 1990, p. 227).

In practice, therefore, the question arises not only of an observer, but also of a corresponding procedure for assessing observations. This is where science has a decisive "filtering" function. Those with the appropriate professional training are better able to recognize whether the observed symptoms should be assigned a "disease value."

1 *Editors' note*: For further information, see: https://en.wikipedia.org/wiki/Itai-itai_disease (accessed 25.04.2025).

In order to gain more knowledge about the process of uncovering problems, the role of individual social groups in discovering negative consequences, in general recognition, and ultimately in coping with the consequences, a well-founded investigation of the processes using current and past cases would be useful. Case studies of this kind on “forest damage” and “pseudo-croup” could probably provide important information about the role of individual social groups in this process.

A systematic search for potential undesirable consequences of technologies is possible if certain search criteria can be found. This task largely falls within the remit of science. Criteria for a systematic search require knowledge of the properties of emitted substances, for example, or knowledge of the observed systems, which can be used to distinguish “normal conditions” from “abnormal conditions.” Knowledge of frequencies, geographical distribution, sensitive areas, and temporal variation is particularly important for the systematic observation of disease symptoms.[2]

2.2 Problem identification through system-oriented approaches

In contrast to retrospective-analytical problem identification, the system-oriented approach is *prospective* and *synthesizing*. Formally, two approaches are possible: *Targeted experimentation to observe the reactions of the systems* and thus gain *direct* knowledge about the negative effects of technologies and products, and the *combination and integration of individual findings, model development, and simulation.*

Targeted experimentation to observe the reactions of the systems

The path of gaining direct knowledge about the negative effects of technologies through experiments with natural systems is only feasible in exceptional cases. Although the advantage of leaving the system in its natural environment is obvious, experiments under realistic conditions might have to expose the system to the very dangers that need to be prevented. Further difficulties arise from the

2 Cadastres are already being planned or installed with this aim in mind (usually referred to as “impact cadastres”). Experience to date has shown that area-wide cadastres are problematic due to their high cost, the often too low resolution for an early warning system, and the resulting “smearing” of regionally limited effects. For “point-based cadastres,” knowledge of sensitive systems or highly polluted and therefore potentially endangered areas is required. In any case, “point-based cadastres” are useful as “probes” alongside area-wide cadastres.

often long periods of time over which realistic experiments would have to be carried out and – for example in studies on the effect of small doses of pollutants – from the large number of studies required to achieve an acceptable level of significance.

Another problem with experiments on natural systems is usually the large number of interfering factors, which are often the reason why the causal relationships cannot be clarified despite careful planning and execution of the experiments. If we consider, for example, the possible effects of emissions from waste incineration plants etc. on ecosystems, it is not possible today to say with certainty what the composition of the emissions is. A permutation of multifactorial impacts and their mostly multifactorial effects often already shows the hopelessness of an exclusively experimental approach to the direct identification of potential hazards.

Of course, measurements are absolutely necessary in order to clarify the impacting factors, e.g., the type and quantity of certain environmental noxae in soil, water, and air, to investigate the spread and deposition of pollutants and their transition rates into the endangered systems. This experimental inventory, e.g., in the form of "substance-related screening" or "exposure-related monitoring," and research into the processes leading to the mechanisms of system damage must be an integral part of an early detection system. However, even with intensive research, complete knowledge cannot be expected, not least because ecological, social, and economic systems are not constant over time. Even under natural conditions, for example, species die out without the influence of humans and technology, and equilibrium conditions change in such a way that individual systems "tip over."

In order to investigate specific influences under defined conditions, which is impossible in natural systems, parts of the system can be investigated under laboratory conditions. It must then be taken into account that certain control loops, symbiotic systems, synergetic or anergic factors are excluded by "cutting out" the natural environment. If, on the one hand, the certainty of knowledge with regard to the system under artificial conditions is increased, the certainty as to whether the natural system will react in the same way as the system isolated in the laboratory is reduced. However, experiments in a closed laboratory open up the possibility of exposing the isolated system to conditions that might already pose a risk in natural systems.

Combination and integration of individual knowledge, modeling, and simulation

In addition to TA studies, this approach is also characterized by the studies of the Club of Rome (Meadows et al. 1973) or "Global 2000" (Barney 1980; Deutscher Bundestag 1988). The approach of these studies is characterized by the cognitive or numerical derivation (construction) of conceivable future states of complex systems on the basis of current knowledge.

The problems and advantages of the non-experimental approach are outlined below using the example of modeling and the simulation of model systems on computer systems. However, these explanations largely apply to all non-experimental system studies. Experimental simulation, for example of flow conditions on city models in a wind tunnel, is not explicitly dealt with here.

The most frequently used method of numerical simulation of complex systems, such as Meadows' world model or the various CO_2 models, can be described as follows: Starting from the real system, a model is constructed that is intended to represent the behavior of the real system with sufficient accuracy. In order to achieve this goal, the knowledge about interrelationships in the system, previous developments, the current state, external influences, etc. – in short, the current state of knowledge – must be compiled and documented. When constructing the model from the mosaic pieces of existing knowledge, the gaps in knowledge crystallize particularly clearly.

In mathematical formulation, models usually consist of systems of differential equations. Based on certain predefined initial and boundary conditions, which are often hidden behind the concept of scenarios, the system of equations is integrated. With this simulation technique, different system states can be examined, so to speak in "fast motion," for the effect of various influences as well as for sensitivity to these influences. Simulation is therefore primarily a technique for researching the dynamics of couplings and feedback in the systems and therefore, in principle, offers the possibility of analyzing correlations and development trends under the conditions set by the "model designer."

Ideally, a complete, tested, and validated numerical model would be an excellent early warning instrument. During the first development phase of numerical model simulation, which was accompanied by much euphoria, many scientists envisioned the design of such forecasting systems. In the meantime, the possibilities of this method for forecasting the future of complex systems following serious quantitative mispredictions (e.g., about energy requirements) have been assessed more realistically and critically by many scientists.

Despite this, high expectations are still being placed on mathematical modeling and computer simulations of complex systems in some circles, both within and outside the scientific community.

To be clear: If, looking back from today's experience, we have to correct some expectations, this is not a reproach against the attempts to forecast future world developments, provided they were carried out and evaluated seriously as simulations of thought constructions and computer experiments. On the contrary: These experiments were necessary in order to sound out the scope of the newly developed possibilities of studying complex systems with the aid of computer technology.

However, criticism is warranted if nothing more is revealed behind the veil of apparent scientificity and apparent rationality than fictions and preconceived opinions.[3]

The impression is often given that a process once translated into computer language can, according to Steinbuch (1974), for example,

> [...] be examined analytically – in a sense – in its structure and stringency, and on the other hand – synthetically – with regard to its consequences under the most diverse conditions.

This may be correct *in principle*; but practice in dealing with large program systems and databases, especially if these are also networked via computer systems, shows rather the opposite. It is quite impossible even for the scientifically trained "everyman" to gain insight into and an overview of external program systems.

When Steinbuch (1974, p. 44) and others attribute to "future" computers a "superiority over the human brain with regard to all rational mental processes," they have unfortunately overlooked the fact that these machines not only increase intelligence, but – "incorrectly programmed" – also increase stupidity.

We must ask, on what foundations these optimistic visions of science stand – or rather – stood.

If we summarize the basis of Steinbuch's opinion that in future humans will only have to specify a value system and that the optimal solution to problems will then increasingly be a matter for computers, which are far superior to the human

3 Every "insider" knows how densely the veil of impenetrability can be woven, especially with today's instruments of mathematical models in conjunction with computer technology. It is not wrong when it is claimed that ignorance, incompetence, and mediocrity are the easiest things to hide behind computer programs today.

brain in terms of rational and intellectual functions, then these foundations are the following:

- The truth criterion of a "regularly correct forecast" based on repeated experiments,
- Rationality of the procedure and the resulting ability to criticize, whereby rationality is assigned very specific characteristics (explained information and procedures),
- The assumption of a constancy in natural processes that can be generated experimentally.

This foundation is none other than that on which the classical natural sciences based their successes. However, measured against the problems for which the early warning system is to be designed, those dealt with very primitive systems.

One example is gas dynamics. The laws of gas dynamics were discovered by studying the behavior of gases, which were easy to study when confined in containers. Naively, one could now believe that a consistent application of these laws in conjunction with other physical laws identified in the same way, such as the law of radiation, would enable a long-term and correct forecast of weather events in the gaseous sphere of our planet. If we now compare the weather forecasts for a prediction time of one week or longer with the development of the real system, the probability of a correct forecast is not too far removed from chance.[4]

The mathematical model formulations of complex technical and scientific systems and their simulation on computer systems are fraught with problems such as gaps in knowledge, uncertain assumptions about the size and correlation of parameters, and results that are difficult to interpret in models of high intrinsic complexity. In the uncertainty of their results, these natural science approaches do not differ from analogous social science attempts to analyze social systems. Furthermore, the actual purpose of scientific policy advice becomes questionable:

> The more differentiated forecasts [based on model calculations; the authors] become, the less suitable they are for justifying political decisions (Teichler 1985, p. 216; see also Luhmann 1969, p. 14).

4 This also applies to long-term forecasts in other areas. There is a biting, but not inaccurate, opinion circulating in relevant scientific circles about the attempts to forecast energy demand: They all have one important thing in common, namely that none of them are accurate.

This could give the impression that the sciences are hardly in a position to contribute to early warning. This is not our intention and is certainly wrong. It is merely to point out that the naive view of the classical natural sciences is not suitable for solving the problem in view of the systems with which an early warning concept for the negative consequences of mechanization has to deal.

If we summarize the previous considerations, we can state the following:

- The scientific methods available for the early detection of developments in large, real, dynamic systems often do not allow for unquestionable findings about causal relationships. The traditional standards of scientific certainty can hardly be met (EWERS 1988). As in the case of long-term technology assessment, for example, we would have to speak of “possible consequences,” of which, for the most part, neither the manifestation can be described exactly nor the course of events predicted with certainty (Bechmann/Wingert 1981a).
- Inevitably, normative decisions (selection of indicators and measurement methods, model constructions, and data selection) are involved in the analytical procedures and the interpretation of results, which are difficult to reconcile with simple notions of neutrality and value-free scientific work (Teichler 1985; Wynne 1983).
- Due to the characteristics of the systems under consideration – such as historically developed uniqueness, irreversible change in the event of interventions, unmanageable variety of potential development possibilities – proven scientific “truth criteria” such as the “regularly experimentally confirmed prognosis,” the reproducibility of the results of the same experiments, the possibility of proving statistical significance, or verifiability by the community – fail in their investigation.

Accordingly, expectations on the part of the political administration with regard to “well-founded scientific evidence,” which are also repeatedly stirred up by industry (Dickson 1981, p. 58), can usually only be disappointed, especially in the field of early warning of technology-related dangers.

However, the *political processing of* relevant expertise is likely to pose even greater difficulties for a practically effective early warning.

3. Early warning as a political problem

Eduard Pestel's pessimistic prognosis that

> [...] it will probably be decades before politicians base their decisions on scientific findings and are prepared to take into account in their decisions catastrophes which, if they act or fail to act, will only threaten in the distant future (Wissenschaft, Wirtschaft, Politik 1984, p. 3[5])

is possibly based on intimate knowledge of the inner workings of power. However, by suggesting that successful early warning fails for the time being due to the subjective inability and unwillingness of individual representatives of the political-administrative system to learn, it fails to recognize the structural conditions and limits for taking scientific findings into account – whether they are of "hard" or "soft" evidence (Ravetz 1984, p. 11).

Even if "exact" findings are available – for example on dose-response relationships in the case of chemicals or pharmaceuticals – administrative consequences are by no means self-evident. Rather, the determination of "safe" limit values for substances and emissions is the product of political decision-making. Their justification is not scientifically possible, "since there is no scientifically comprehensible trade-off between health and freedom, between social security and nature conservation and similar values" (von Lersner 1983, p. 138f.). Embedded in social conflicts of interest (Weidner/Knoepfel 1979, p. 161), the process of political-administrative problem processing decides "what is dangerous" (von Lersner 1983, p. 133). This became clear, for example, in the public disputes about the "Hazardous Substances Ordinance" ("Grenzwerte für giftige Stoffe politisch gesetzt", Frankfurter Rundschau, 18.4.1985) and about radioactive contamination after Chernobyl.

In addition, numerous problem areas and potential hazards are already known today that no longer require early warning. We can think of the common problematization of causal relationships (energy production, industrial production, agriculture, waste management, car traffic, and households), "prominent" toxic substances (formaldehyde, dioxins, PCBs, atrazine) as well as threatening levels of damage to elementary ecological systems (soil poisoning, water quality, ecological death in the North Sea, forest dieback, reduction of biodiversity). Also, much damage to human health associated with critical environmental conditions is no longer waiting to be discovered through early detection (environmentally

5 *Editors' note*: No bibliographic details were provided in the original publication.

induced increase in allergies, cancer incidence, respiratory diseases, workplace-specific diseases) (Koch 1985; Umweltbundesamt 1984).

In most of these problem cases, there were complaints that politicians "do nothing or too little" (Koch 1985, p. 6). The population seems to share this view. According to a survey conducted by the Ipos Institute in 1985 on behalf of the German Federal Ministry of the Interior, only 18 % of all respondents "believe in successes in environmental protection since the Bundestag elections in March 1983" (Frankfurter Rundschau, 16.8.1985). According to an opinion poll of the Institut für Desmoskopie Allensbach, 28 % of respondents trusted the Minister of the Environment to solve the tasks set, while 72 % had confidence in Greenpeace in this respect (Handelsblatt, 17.10.1989). In the view of many experts, the measures taken by the political administration are usually not far-reaching enough. This can be illustrated by the example of forest dieback and the policies pursued in this context (Large Combustion Plant Ordinance, Technical Instructions on Air Quality Control (TA-Luft), speed limits, catalytic converter cars) (Bechmann et al. 1985, p. 409).

This makes the question of the structures and mechanisms of the ultimately decisive political and administrative processing of warnings about the consequences of technology all the more urgent.

3.1 General selection services of the political system

Only a few studies have systematically reconstructed cases of failure to provide early warning or failure to recognize dangers (Crenson 1971). However, from existing studies on the functioning of the political-administrative system, as has become clear in various policy areas[6] (Russ-Mohl 1982, p. 3ff.; von Prittwitz

6 Von Prittwitz explains the development of environmental policy from "different factor complexes," namely "the state of action capacities and environmental pollution. However, each set of factors is of unequal importance. Effective environmental policy can only develop if sufficiently large technical-economic and political-institutional capacities for action are available. If these are lacking, even the most severe environmental impacts will not lead to an effective response. Environmental pollution, environmental crises, or disasters are only possible triggers or amplifiers of environmental policy action on the basis of sufficient capacity for action. If this is the case, the calculations of goal-oriented environmental policy generally gain in importance. Environmental policy therefore often intensifies as the capacity to act increases or as problems are overcome; it therefore primarily expresses the state of the capacity to act and has a more pro-cyclical than anti-cyclical character" (von Prittwitz 1990, p. 114f.).

1990, p. 103ff.), some general insights can be gained that are relevant for the "recognition" of technology-related hazards.

Every differentiated social subsystem, including the political subsystem, has the basic problem of securing its existence in relation to the social environment and its demands by reducing and processing its complexity in accordance with its functional requirements (Rucht 1982, p. 37). Accordingly, the political-administrative system can be characterized by *general selection mechanisms* that distinguish it from the other subsystems. With regard to social problems, Russ-Mohl rightly states:

> There are many problems [...]. Very few overcome the threshold of repression and non-decision and thus become a *political* issue (Russ-Mohl 1982, p. 6; emphasis added by the authors).

The attention and thematization criteria of the political system[7] are particularly relevant to the question of early "recognition" of impending dangers. They are what make a named problem in need of a decision in the first place.

Luhmann includes:

- the perceived threat to overriding social values;
- crises that jeopardize the functioning and existence of the political system;
- the socio-political status of the person addressing a problem;
- symptoms of political success that seem to be associated with the adoption of an issue;
- already occurring "pain or civilizational pain surrogates" (e.g., loss of income) in connection with a problem situation (Luhmann 1970, p. 13).

The process of an issue entering the political arena is further accelerated by events such as the exacerbation of problems as a result of cumulative effects or protests by those affected by the problem (Russ-Mohl 1982, p. 6; Mayntz 1983, p. 335).

These rules of attention refer to the structure and "ratio" of the political-administrative system, whose elementary communication medium for the production of binding decisions is "power" (maintaining and gaining power), while the

7 It is not enough for a problem to have already attracted public attention for it to become the subject of political processing. Many problems are recognized relatively early on – after the effective "attention rules" of the political system, "decision rules" come into force, which decide on the type and manner of the measures ultimately taken (Luhmann 1970, p. 11).

communication medium “truth” of the scientific system or “factual rationality” plays a rather subordinate role in its processing (Mayntz 1983, p. 334).

It must therefore be possible to translate problems into the frame of reference of gaining and maintaining power for individual politicians, parties, or the entire political system. The decision-making rules and the question of the implementation of measures to be adopted are also determined by the rationale of the political system. In addition to the decision-makers’ interest in their own political survival, Mayntz points to the criteria of the “feasibility” of problem solutions as well as the material and financial restrictions. Political feasibility means the support of measures and their implementation by relevant actors in the political arena or “acceptance” by the population; financial feasibility is ultimately based on the political influence of the respective interested parties and their ability to present the measures to be implemented as particularly urgent (Mayntz 1983, p. 334).

The analysis of the general selection mechanisms and the ratio of the political system therefore leads to the following conclusion: What also applies to technology assessment applies to the chance of scientific expertise being taken into account: The improvement of its cognitive quality (methodology, validity), which is certainly desirable, is far less decisive than its compatibility with political criteria and processes. “Technology assessment [or early warning; the authors] therefore requires advocates with sufficient power within the decision-making system” (Mayntz 1983, p. 339).

3.2 Social and institutional boundaries

The general selection mechanisms outlined would now have to be specified in more detail for given political systems.

At this point, we will only draw attention to some of these *specific selection achievements*, insofar as they can be related to the consideration of technology-related dangers for people and the environment in Western industrial societies.

Following Offe, a distinction can be made between the structural, ideal, and procedural levels (Offe 1972, p. 79ff.; cf. Bachrach/Baratz 1977, p. 87ff.):

- *Structural selection services* are provided by the overarching historical, socio-structural, and economic framework conditions of a political system, which are reflected in its basic constitutional and institutional provisions. In this way, a preliminary decision is made as to which issues and matters can become the subject of state policy at all, and which premises and scope for action apply. In the area of environmental policy, for example, the structural selection achievements in the public debate on the relationship between economy and ecology become visible. In principle, ecological issues can only be raised in the political arena and considered with proposals for solutions to the extent that they are compatible with market economy conditions and means (Offe 1972, p. 83).

- *Ideational selection services* are provided by the prevailing socio-cultural and political system of norms and further restrict the structurally available scope for action of the political system. Such selective norms range from the slowly changing dominant value orientations of society, established political preference structures, and legally standardized norms to the frequently discussed "sensitivity" of social actors to specific problem situations. For example, it was the "lack of sensitivity to the ecological hazard potential" that characterized the Hamburg Senate in the opinion of a parliamentary committee of inquiry, despite the existence of legal possibilities for action and control in the case of the Georgswerder hazardous waste landfill (Der Spiegel, 4.3.1985).[8] Of greater importance in this context may be the criteria according to which the necessary balancing processes between conflicting economic, social, and environmental policy objectives are carried out with regard to an early assessment of technology-related hazards and the costs of averting them. To date, for example, it cannot be assumed that the costs of eliminating environmental damage are systematically included at the macroeconomic (or even business management) level (Simonis 1988).
- Finally, *procedural selection services* are provided by the formal and informal procedures of policy formulation and their implementation, which in turn predetermine the possible content or the possible outcome of the processing of early findings on technology-related risks. In this way, certain interests and content are given greater chances of being implemented, while other topics or social actors tend to be excluded from these procedures. With regard to "collective bargaining" between associations and state authorities, it has often been complained that "nature" has no lobby.

  The same applies to socially underprivileged groups, or groups with little capacity for conflict, who are often burdened with the costs of crises and state crisis policy (Russ-Mohl 1982, p. 25). Their interests are usually difficult to organize; they lack material, human, and information resources and expe-

8 For further information, see: https://www.internationale-bauausstellungen.de/en/history/2006-2013-iba-hamburg-leap-across-the-elbe/energy-hill-georgswerder-a-landfill-becomes-an-energy-hill/ (accessed 16.04.2025).

> rience in dealing with political procedures. In contrast, the "interests of those who cause [problems; the authors] are usually (and especially when they are producer interests) represented in the political system through clientele relationships," and "this circumstance can (even without lobbying efforts explicitly related to the problem) already be sufficient cause for denial or neglect of the problem and non-decision on the part of politicians" (Russ-Mohl 1982, p. 5).

The analysis of the specific selection mechanisms shows that: In the political system, early warning of technology-related dangers must reckon on the one hand with the influential dominance of interests and values that are linked to industrial progress and the market economy, and on the other hand with a tendency to repress interests and values that have a low capacity for organization and conflict. Environmental protection and the improvement of "quality of life" for broad sections of the population must still be counted among the latter (Frederichs et al. 1983, p. 17ff.).

From two sides, the selection mechanisms of the political system obviously pose particular difficulties for early warning, with far-reaching consequences:

- As explained above, the expected expertise is generally even more "uncertain" than the already established scientific policy advice. In this respect, it is even more dependent than the latter on a promising transmission into the political arena – and that means: On "advocates" who can mobilize political power for their recommendations.
- Since the subject matter of early warning concerns dangers and damage that have not yet occurred (on a large scale) and/or do not (or cannot) affect any dominant interests in the political system, early warning has a particularly low chance of finding such advocates and generating a willingness to act.[9]

Accordingly, it is much more likely, and paradoxically a background experience for the call for early warning, that the aforementioned structures in the political system do not initially give rise to any real willingness to deal with an indicated problem situation. Scientific expertise tends to be received according to the extent

9 In this context, one could also point out that heeding warnings is politically a thankless business. In any case, it causes high costs and does not necessarily pay off in the case of a "successful alarm" (Clausen/Dombrowsky 1984, p. 302), as it destroys the proof of the soundness of the warning at the same time as it eliminates the danger. For the audience interested in the politician, a professionally correct warning can then no longer be distinguished from a false prophecy.

to which it helps to "objectively" justify the rejection of recommendations and demands (Mayntz 1983, p. 337). If this reaction is no longer sufficient, "symbolic politics" is used to give the impression to those affected and the public that the political administration "has things under control" (Mayntz 1983, p. 335; Russ-Mohl 1982, p. 7; cf. Bechmann et al. 1985, p. 409).

It can therefore be assumed that all attempts to improve the cognitive performance of early warning must remain practically futile if the chances of its transmission into the political arena cannot be improved. But given the specific selection criteria, how is expertise supposed to find influential advocates in the political-administrative system at an early stage?

4. Opening up the political system to science and the public

Initially, it seems obvious to look for advocates who already play a more or less important role in the political decision-making process. In concrete terms, the known cognitive, normative, and functional problems in communication between experts issuing warnings and political actors present themselves as obstacles. Recommendations encounter difficulties in understanding, reservations on the part of political actors with regard to value premises, and perceived impairments of their sole decision-making authority (Mayntz 1983, p. 336ff.). However, dealing with trans-scientific issues in particular requires the organization of a communication context not only in terms of content, but also institutionally, in which the classic distribution of roles between the politician as decision-maker and the scientist as advisor is gradually abandoned. Van den Daele et al. have coined the term "hybrid community" for this new network between politics and science. The selection and discussion of the relevance of different research approaches, the strategy to be pursued, and the evaluation of the results must be jointly discussed and represented. In doing so, the representatives of politics and administration must engage with internal scientific problems and link their decision-making premises to scientific discourses (van den Daele et al. 1979). Such hybrid communities can already be found to some extent in various areas of project-oriented research. The Enquete Commission in the German parliament also represents such a case. The formation of a hybrid community oriented toward early warning would be supported by the fact that the politicians involved in it would certainly represent the resulting warnings in the political system with greater commitment and dedication.

A second consideration for finding suitable advocates for early warning in the political system lies at the level of organizational and procedural institutionalization. With regard to the comparable problem of raising the chances of technology assessment being taken into account, it would appear to make procedural sense to prescribe early warning by law, and at least its acknowledgement in the process of political decision-making (Mayntz 1983, p. 340f.). However, this perspective fails to recognize that the individual actors also make or are subject to the general and specific selections that are responsible for the fundamental dilemma of early warning. In other words, an institutional allocation of early warning capacity to the highly influential ministerial bureaucracy in Germany in no way guarantees that the latter will exert its influence on expected warnings. Precisely by keeping expertise out of political-parliamentary controversies (Mayntz 1983, p. 341), the danger of its dethematization would grow under the given circumstances.

At the same time, this highlights the fundamental limitation inherent in all proposals to seek advocates for early warning only among the actors already dominant in the political system, or to reduce the problem to the communicative, procedural, and institutional relationships between science and politics.

A relaxation of the specific selection mechanisms for the recognition of technology-related dangers can only be expected, taking into account the rationale of the political system, if systematically excluded interests, values, and actors are given easier access to the debates in the political arena. Conditions must also be created in the relationship between the political system and the public that promote the willingness to recognize and deal with dangers.

Similar to technology policy decisions, the perception and political treatment of early warning should also be understood as a social conflict and consensus-building process. Accordingly, the public should be involved in the initiation, implementation, and evaluation of early warning expertise (Paschen 1983, p. 425ff.; cf. OECD 1979, p. 114):

- In the early warning initiation phase, public participation can help to identify problem areas and issues for early warning. This is the only way to ensure that social needs and interests are taken into account at an early stage and on a broad basis.
- In the implementation phase, public participation should, within certain limits, promise the development of additional knowledge resources (cf. Sec. 2). Such experiences have been made not only in the context of technology assessments, but also in various areas of government planning (Hucke et al. 1984, p. 214ff.; Türke 1981, p. 1). The inclusion of representatives of the public

in advisory and control bodies of early warning-oriented research should also be considered (Mayntz 1983, p. 343).

- In the phase of discussion, evaluation, and administrative processing of results, public participation improves the chance that warnings and identified hazards will be recognized by more social actors and broader sections of the population, and may prompt action.
- In this way, early warning would be more likely to meet the political system's criteria for thematization. At the same time, instances within the political system itself are likely to be found more quickly, which, in view of the political benefits that can now be expected, will become advocates for the warning.
- Finally, by making the early warning results the subject of a broader public debate, the possibility of finding support for the measures to be taken and their administrative implementation also increases. It is well known that political measures in the field of environmental protection are particularly dependent on such public support.

If these considerations are systematically applied to the modification of those selection mechanisms of the political system that hinder effective early warning, then public participation could have two main effects:

On the one hand, it would lead to an expansion of the values, interests, and political preferences taken into account (ideal selection), and on the other hand, it could generate a willingness to act via the lever of the political actors' need for support and legitimization (procedural selection). In this context, it is not least important that the scope for action of administrative actors would be increased in relation to the often dominant social interests in the political system with reference to the attitudes and demands of the public (Hucke et al. 1984, p. 219).

Although it must be conceded that the political decision-making process and administrative control through public participation in early warning expose themselves to greater expectations, there is no guarantee of successful social consensus building on dangers and countermeasures to be taken (Bechmann/Wingert 1981a, p. 324; cf. Paschen 1983, p. 364). Just like the dissolution of the rigid boundaries between science and politics through problem-oriented hybrid communities as carriers of early warning, the opening of the political-administrative system to the public also contains risks. However, this appears to be the price that must inevitably be paid if the risks of a lack of early warning or incrementalist management of technological consequences are to be avoided.

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