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Consequences, addressees, patterns of institutionalization and rationality: Some dilemmas of technology assessment

Preliminary remarks: TA – what else?

Technological development and its effects have been caught in the crossfire of public debate. The demand for an appropriate assessment of technical products and sensible social and political control of scientific and technological progress is sometimes elevated to a secular problem for the survival of highly industrialized countries. Nevertheless, the mechanization of nature and society continues unabated in both East and West. The simultaneity of the actual acceleration of technological development and the increase in critical discourse about the consequences: This is the dilemma of today's social situation.

If we look back at the history of industrial societies and consider the social controversies of the last eighty years, we can see that the public discussions about the prerequisites and consequences of technological development and the social evaluation of technical products and processes are not so new.

In a historically oriented study, Meinolf Dierkes shows that the history of technological change and the associated process of industrialization have always been characterized by political and social disputes that focused on the social impact of new technologies (Dierkes 1986; Sieferle 1983).

Similarly, since the industrial revolution, there has always been an evaluation of technical products and technical production processes. The market and the state were the central bodies for regulating technical progress. All of this has been reflected in the innovative behavior of companies and in government regulations for technical standards (Wolf 1986). Nevertheless, it would be wrong to regard today's controversy as *a* repetition of old arguments.

The current public debate differs from all previous social debates about technology in at least three respects. Today, three topics are the central focus of interest: the cultural self-image of humankind, the legitimization of the industrial-technical model of progress, and the ability of politics to control. The linking of these three aspects makes the critique of technology the center of social power

struggles, as new structures of influence and new patterns of legitimation for the exercise of power are being fought over.

Cultural self-image

The process of mechanization no longer takes place centrally in the production sector of industrial society, but rather, due to the development of large-scale technologies such as information and biotechnologies, almost all areas of society are confronted with an increased use of technology and placed under pressure to rationalize. At the same time, areas of the human being that previously constituted its uniqueness are being mechanized: mental activity and biological reproduction. With interventions in these areas of human existence, human nature is made contingent (van den Daele 1985, 1986): For the first time in evolutionary history, human beings can change the conditions of their own evolution.

As we can learn from the debate on artificial intelligence and genetic engineering, this awareness has a profound impact on our cultural self-image (OECD 1983; Hohlfeld 1988; Turkle 1984). The demand for new ethics is probably only the initial stage of a changed view of humanity. The potential dangers of modern technologies and the novelty of technical access to natural processes are changing all previous standards and evaluation criteria. There is a need for a public discussion of the consequences of scientific and technological progress.

Loss of legitimacy of scientific and technological progress

In the last decade, the legitimacy of scientific and technological progress has been publicly questioned to an unprecedented extent in most highly developed industrial societies. In the 1950s and 1960s, technological change enjoyed a broad consensus among the population. Technological progress was seen as a necessary condition for increasing individual and collective prosperity. The increase in social prosperity was seen as compensation for the frequently registered negative effects of technological change, such as de-skilling, de-professionalization, redundancy and unemployment. The universally legitimized separation between the prerequisites and consequences of technological progress provided the basis for reducing the problem of the social costs of technological development to questions of regulation and distribution, which could then be solved in monetary terms. With the emergence of the environmental protection movement, a protest potential arose on the periphery of society that called this basic consensus into question (Braczyk 1986; Raschke 1985). The thesis of the ecological crisis means more than just the elimination of unpleasant consequences of technology; it questions the preconditions and the meaning of technological development as

a whole. The protest is not defending old privileges or threatened values – at its heart is the rejection of a socialization process that is in the process of destroying its own foundations. The industrial system itself is thus put up for debate (Eder 1986; Touraine 1986). The collapse of the previous social consensus model becomes clear in the opposition to the most brilliant products of technical progress: instrumental reason and large-scale technologies.

The point seems to have been reached where the social and cultural costs of further technological development can no longer be offset by economic benefits. The integrative power of the scientific-technical consensus model has become fragile. The path to post-modernity has many forks (Offe 1986).

Loss of political control

The change in cultural awareness and the loss of the legitimizing power of technological progress have also left their mark on the institutions of the political system. The demand for the institutionalization of technology assessment in parliament [...] indicates that the consequential problems of technological development are also increasingly playing a role in politics. As early as the 1960s, Ernst Forsthoff pointed out the structural change in the state triggered by technological change ahead of his time (Forsthoff 1965).

Forsthoff saw the identification of the state with the technical process as a danger of losing the autonomy of state decision-making. This could happen either by transferring decision-making power to the technical-scientific elite or by incorporating technical goals into the state's objectives. Forsthoff's fears have been far exceeded by actual developments. Not only has the state become the promoter of the technical process in many areas of technological development – the cases of nuclear energy and biotechnology are just two particularly spectacular examples of the state's involvement in technical realization – it has also lost the power to define the legal and ethical boundaries (Luhmann 1986). Two complementary developments play an essential role here:

- The risks that can arise from the use of technologies and the implementation of major environmentally relevant projects have become more far-reaching and complex.
- Public awareness of the risks associated with the use of technology has grown considerably.

Both developments mean that technology control has become more complex and more demanding. Today, it is not only economic and health assessment criteria that are decisive for the areas of technology standardization. Social and ecological

risks must also be included in the assessment system, particularly due to pressure from public opinion.

However, what is perceived as a danger and what is to be assessed as a danger is largely determined by science (Beck 1986). In the field of technology control, politics is already dependent on science when it comes to defining and determining possible and necessary courses of action. The Chernobyl nuclear reactor accident in 1986 made this drastically clear to the public (Krohn/Weingart 1986).

The changed cultural situation, the decreasing legitimizing power of technological progress and the lack of political control have led to an intensified public discussion of technology assessment. Today, the search for a social technology assessment procedure determines the social discourse in the field of scientific and technological progress. But what can be understood by technology assessment?

1. Technological consequences and "forecasts" of technological development

The term "technology assessment" or "technology evaluation" stands for a program of a new form of interdisciplinary technology research. With the help of TA analyses, the effects of the initial application of new technologies or technologies under development are to be researched and evaluated systematically, comprehensively and as early as possible, with a focus on the unintended secondary and tertiary effects, which often occur with a considerable delay. At the heart of the analysis is the foresight of possible positive and negative consequences of a technological development, as well as the provision of scientifically sound and decision-oriented information on the basis of which it is possible to shape technological progress in a way that is both socially and environmentally compatible (Bechmann 1986; Lohmeyer 1984).

TA analyses are *problem-oriented* research that is located between basic research and applied research (de Bie 1973). While basic research is to some extent self-reflective, answering only the questions of the research itself, applied research follows criteria of useful application and thus means the practical application of knowledge, problem-oriented research starts from a socially defined problem and attempts to find solution strategies.

The theoretical core problem of a TA study is the prediction of technology-induced or technology-influenced changes. This opens up two problems that have not yet been solved satisfactorily:

- What are the consequences of a technology?
- How can they be predicted?

Let us first look at the concept of consequences. At first glance, it seems trivial to talk about the consequences of individual technical artifacts. Doesn't the telephone directly change the way we communicate? The consequences of a technology are then understood to be changes in behavior, attitudes, opinions and knowledge that are directly caused by the use and application of the technology. In many cases, the consequences are interpreted within the framework of a stimulus-response model, namely in the sense of technological determinism, which claims that the development of technology is controlled by its own laws and that people's behavior and the structure of social institutions are determined by the technology (Ogburn 1969). The problem with this approach is that the state of technology is seen as an independent variable and thus postulated as the actual cause of social change.

We should be extremely cautious about these ideas or monocausal explanatory strategies, because at second glance – which should actually be scientific – we see that it is not technical devices or technical development that are the cause of human action, but that each stage of technical development is compatible with many more behavioral patterns than technological determinism suggests.

Industrial sociology has amply demonstrated that the "consequences of technology" depend on the way in which it is implemented, so that the respective form of social embedding must be regarded as an intervening variable in the causal relationship between the technical innovation and its social consequences. Social or societal consequences of technology are primarily *consequences of the actions of actors*. Nevertheless, the scope for action in the application of technologies is of course not arbitrarily large; it is limited by the technologies themselves. With reference to numerous empirical studies, G. Mesthene, the director of the former Harvard University Program of Technology and Society, has attempted to grasp this connection between technology and social structure more precisely (Mesthene 1970). He formulated a theory of "soft" and "probabilistic determinism."

Technical innovations create new possibilities for action and choice, new potential to achieve new goals or to realize existing goals in a different way. However, in order to be able to use these possibilities in a planned manner, new ways of social organization and institutional changes are required. Technical innovations change hierarchies of goals and values and therefore also social conflict patterns – but only in the medium of social communication. "Soft" determinism can be described as the realization that new technologies open up opportunities

for action, devalue social institutions and make cultural patterns of action less persuasive. At the same time, however, it remains open to an extent how this newly created space for action can be filled, or regulated by new institutions.

One can also speak of a trend reinforcement that is achieved through technical possibilities in the social sphere. The use of technologies is determined not least by existing social interests and forces. Reese even believes that the existing development trends in the respective area of application are merely reinforced (Reese et al. 1979). Examples of trends are administrative rationalization, corporate concentration, increased control measures, etc. Recently, reference has also been made to the different lifestyles that determine and shape the consequences of technology application (Rammert 1989).

All in all, the concept of consequence effect, which is too tempting for deterministic ideas, should be replaced by the concept of potential.

This is where a theory of the use of technology, or a "theory of dealing with things," should start (Joerges 1979). According to this concept, technical artifacts only have a "potential function," while the real function is only constituted in the concrete ways in which they are used. Once the potential functions of a technology have been determined, one can attempt to grasp the real function with the help of social science research, whereby the technical possibilities must always be understood as social and societal possibilities for action.

The *prediction* of possible or probable social developments in connection with technical innovations is a topic of particular interest to scientists and politicians in connection with TA studies (Frederichs/Blume 1990).

Forecasting can be understood as the attempt to use as much available information as possible to determine which future developments in a defined area can occur with a certain probability under certain conditions. According to Knapp, explanatory forecasts should be distinguished from so-called "inexact" forecasts (Knapp 1978). Explanatory forecasts have long been the subject of scientific-theoretical discussions, whereby forecasts in this context are understood as statements that can be derived purely logically from laws and boundary conditions. In the case of TA, this type of forecast is likely to play a minor role, as the necessary legal knowledge will rarely be available. Forecasts are characterized by two features: Their statements are statements of expectation and the expectation preferences expressed in them must be justified. If this justification cannot be made on the basis of legal knowledge, one will have to resort to trend forecasts and expert forecasts (Helmer/Rescher 1959). In both cases, an attempt is made to describe the basic structure of a change, and the direction and the speed of changes as both tendencies and inherent possibilities. In addition, a well-founded assessment

of a development is required, which then results in the preference of one future extrapolation over possible other extrapolations.

Empirically meaningful statements can only be made if the most important parameters are fixed over a defined period of time. A special form of this so-called conditioned prediction is the action-dependent or action-related prediction. Here, the occurrence of the predicted states and events is made dependent on specific actions of the forecaster or other persons, so that the actor has particular possibilities to influence the realization of the prediction, i.e., to bring about the conditions. The decisive question and thus the central problem of prognostics is how probable a given prognosis – wherever it may come from – is in absolute terms, or in comparison to alternative prognoses, and whether the empirical basis presented for its empirical-inductive justification can be regarded as sufficient according to intersubjective criteria and requirements. Additional difficulties arise in the field of social sciences and in particular in the area of the interdependencies between technological development and social change, as there is only a limited amount of theoretical knowledge and well-founded empirical data available. In contrast to the economic sciences, where there is agreement on the concept of national accounts, no valid measurement and classification system for technical progress has yet been developed. Each analysis works with its own concept and definitions.

Furthermore, it has not yet been possible to isolate the effects of technological developments, e.g., on labor market conditions, qualification and economic structures, from other influences, such as economic cycles or the influence of global economic development. So far, only relatively arbitrary attributions exist. The development of early indicators for chains of effects that can indicate the diffusion of technical development with a degree of reliability is encountering major difficulties.

This is a link with innovation research, which describes what is technically possible or has already been developed, but cannot indicate which innovations will spread in which way, at what speed and in which area. The decisive factors for this are economic aspects such as cost reduction, cost structure, demand, price elasticities, etc., which are not accessible to technical research instruments.

It is even more difficult when it comes to forecasting changes in values or organizational changes. Futurology, which used to be conducted with great enthusiasm, no longer seems to be in vogue.

If exact statements about possible consequences or side effects of technical innovations are not possible, then TA analysts should commit themselves to developing structural analyses and theoretical knowledge that can then guide

the impact analysis, whereby it is initially important to identify bottlenecks, important development trends or contradictory patterns of action. An important task thus arises in the continuous observation and analysis of technical and social change, whereby an attempt should be made to link exploratory forecasts with empirically sound assumptions.

Kern/Schumann have introduced the term "bandwidth determination" for this purpose:

> We can thus characterize our method of prediction in summary as theoretically guided and empirically supported bandwidth determination. "Theoretically guided" because we refer to a theory of capitalist development that is based on the distinction between logic and forms of rationalization and contains specific assumptions about the change of form [...]. "Empirically supported" because we use empirical means to prove that the old forms are beginning to be replaced by new concepts of production. The concept of "bandwidth" is intended to define fields and boundaries within which the development can be expected (Kern/Schumann 1985, p. 378).

Thus, in a purely logical sense, forecasts of the indicative type are dispensed with, and one restricts oneself to naming danger points and limits of development. However, this is an opportunity to obtain empirically sound statements without having to submit to the constraints of a deductive forecast.

2. Technology assessment in the political process

The interesting thing about technology assessment is probably its close links with politics: it is constitutive for TA and the real cause of annoyance for critics.

Only this direct link between TA and social practice explains why the TA debate includes not only questions of scientific analysis but also questions of the governance of scientific and technological progress, and questions of institutional reform of the political system. The problems and difficulties associated with this will be examined below (Paschen et al. 1992).

2.1 Discrepancies between scientific and political action orientation

As differentiated systems of action, politics and science differ significantly in terms of their objectives, working methods and forms of organization, meaning that the knowledge generated in the science system cannot be directly translated into political action. It is therefore right to speak of a transformation or implementation process in this context.

The researcher is obliged to comprehensively process existing knowledge and to systematize it from a theoretical and empirical point of view. The aim must be to gain knowledge about reality strictly according to methodological rules that can be verified intersubjectively. Scientific work is a lengthy process that requires both coordination with one's specialist colleagues and discussion in the wider scientific community. Research processes often require long periods of time, and the results are sometimes controversial and in many cases hypothetical in nature.

Politics is quite different. Political action is based on consensus and conflict processes and is aimed at reaching binding decisions. Decisions usually have to be made under time pressure with no certain consensus. Information is important for decision-making, but the information base is limited and solely aimed at facilitating the decision to be made, not at comprehensively illuminating the decision-making problem. It is about dealing with a unique situation, not about finding laws. Complete information that meets scientific standards would lead to an oversupply of information and thus make political decision-making more uncertain.

This brief comparison of politics and science already shows that the mediation processes cannot be solely a matter of communication problems, as is often suggested in the literature (Bartholomäi 1977). Instead, one must start from the structural discrepancy between the two fields of action and attempt to mediate the different orientations institutionally. This is necessary insofar as policymakers are dependent on scientifically sound support.

Renate Mayntz has pointed out that the process of translating scientifically generated knowledge into political decisions is not primarily about the instrumental processing and implementation of knowledge, but that contextual factors of political action play a much greater role than is generally assumed. It is not the most effective solution to a factual problem that is at the center of the politician's action orientation, but rather the speed of the decision, the conservation of scarce resources such as money or prestige, the avoidance of unnecessary conflicts and, last but not least, the possibility of political self-expression (Mayntz 1977, 1983). Improving the rationality of political decisions through science thus comes up against limits set by the political system.

2.2 On the specific implementation problems of TA studies

It seems as if the existing difficulties in guiding political action through scientific analysis are becoming even more acute in the field of TA. The original hope that better information would be generated with the help of TA studies, which would

then automatically lead to better decisions, has been significantly relativized in the course of TA discussions.

A TA study faces at least three fundamental problems that need to be solved before it can be translated into practical action. These can be described as scientific, organizational, and power-related barriers to the application of TA.

The *scientific difficulties* result from the interdisciplinary nature of projective TA studies. The scientific disciplines involved have varying degrees of ability to provide the necessary information on developments and interrelationships. Since every impact assessment has to deal with different variables, developments and interrelationships in both social and ecological systems, the specific investigations fall within the scientific scope of numerous disciplines. The diversity of possible effects (economic, technical, ecological, social, political, legal, medical, etc.) as well as the fundamental interdependence of technical development and change in many non-technical areas of reality make the cognitive components of the TA process a necessarily interdisciplinary task. The particular problem now is to combine the specific research perspectives, theories and methodological tools in a targeted manner. It is therefore necessary to turn pure multidisciplinarity, in which the knowledge of different disciplines is merely brought together, into *integrated interdisciplinarity*, which is based on the genuine integration of individual perspectives. In addition to the problem of interdisciplinarity, there are also epistemological limitations that play a role in the application of TA.

When predicting consequences, TA researchers generally have to deal with non-linear and non-deterministic systems. Neither the technical entities themselves, nor their embedding in non-technical framework conditions, nor the reaction of individuals, social groups and institutions, nor the intervening socio-cultural processes can be precisely described in advance. Unforeseen developments in science and technology, exogenous events such as natural and technical disasters, and political and social changes can render all forecasts and simulation models useless. No anticipatory impact assessment can capture all influencing factors whose possible variations may affect the complex and dynamic interdependence of technical and social change. Complete information remains an illusion. The unavoidable occurrence of uncertainties seems to be the salient feature of all attempts at technology assessment.

Scientific analysis cannot provide binding guidance for political decision-making. Statements about the consequences of technology are largely hypothetical in nature. The implementation of such interdisciplinary and projective research therefore requires additional communicative effort in order to clarify the hypothetical nature of these statements to the users.

Due to the projective nature of TA studies, subjective and value-based decisions are unavoidable. All effects and interdependencies can never be fully understood; at some point, the study must be terminated. Normative points of view and strategic considerations thus form the framework of a TA study, which, however, do not necessarily have to be shared by all customers. It is therefore necessary to disclose all value decisions, all delimitations and selections, and in particular also assumptions that are necessary because sufficient data is not available. Only an impact assessment that is "objectified" in this sense allows for systematic control and criticism.

In view of the different interests, values and preference structures in society, TA studies always run the risk – due to their cognitive uncertainty and explicit normative commitment – of triggering conflict processes in socio-political disputes, so that their actual statements are pushed into the background in the face of controversial evaluations. As Renate Mayntz has rightly seen, social promoters of TA analyses are needed here (Mayntz 1983).

The organizational barrier for the application of TA results from the difficulty of prediction and control due to the fact that technical development is not produced centrally – rather the production and use of technical innovations falls within the decision-making competence of different social groups. TA analyses must therefore always be oriented toward different interest groups, which naturally differ in their assessment of the costs and benefits of a technology. This makes agreement on the normative premises of an investigation an essential prerequisite for successful application.

TA analysts must ensure that not only their research results are interpreted appropriately by the user groups, but also that by intensifying cooperation it is ensured that problem definition and problem solving are coordinated with the requirements of compromise formation between the relevant political groups. This presupposes that a transformation of scientific knowledge into action knowledge takes place in the application process – in other words, scientific knowledge is placed in a concrete norm and application context. The prerequisite for this transformation is the orientation of the TA analyses toward three requirements:

- the degree of pragmatic statements,
- the degree of compatibility with the existing values, goals and norms of society,
- the degree of evaluative interpretability.

The more pragmatically oriented knowledge is, the better it can be translated into technical recommendations for action. In this respect, the engineering sciences,

medicine and also jurisprudence have fewer problems with the application of scientific knowledge than the so-called humanities, where the act of verbalizing and interpreting the results of scientific expertise must still be added for a meaningful translation into practical knowledge.

The discussion about the consequences of technological development today is to a large extent a discussion about the values of those involved, be they producers, politicians, those affected or other stakeholders. The process of technical innovation is always a process that involves the distribution of risks, benefits and costs and in which fundamental value orientations are affected. Where fundamental value decisions are affected, the willingness to accept TA results – especially since they still have an uncertain cognitive basis – is low. Uncertainty in the prediction of technological development and the incomplete determination of its effects enable interest groups to ignore TA analyses due to their value orientation and political objectives.

The question of the compatibility of the TA analyses with the values is also related to the degree of evaluative interpretability. The degree of evaluative interpretability primarily determines the possibility of reading information with regard to different values and objectives. The more clearly recommendations are made, the easier it is to make decisions. The disadvantage of this application reference, however, is that the more concretely the decision-making aid is formulated, the more likely it is that the TA analysts will have to take sides and thus destroy the very basis of their statements, i.e., scientific independence.

The third barrier that determines the application of TA analyses is the *integration of TA processes into the power relations of the political system.* As applied, practice-oriented research, TA must be related to the political decision-making process, but it must not be appropriated by short-term objectives and problems and thus eliminated from its actual role. TA research is faced with the difficult task of finding a sensible balance between integration and distance. If we bear in mind that the most important decisions in a TA process take place in the triangle formed by science, politics and the public, we can immediately see that TA is embedded in a field of social debate.

Since TA provides information both for political decision-makers and for the public, TA producers find themselves in a power struggle because their analyses affect the value premises and justification strategies of those involved in TA processes. Whether they like it or not, the TA analysts are ascribed a part of the political decision-making power and thus enter into competition with the political decision-making bodies.

Renate Mayntz has derived three restrictions for the application of TA analyses from the reference to political power:

- The seemingly modest claim of TA to provide information for political decision-makers is in reality by no means modest. It implies a claim to participation in political power and brings the people who produce TA into conflict with political decision-makers who, by virtue of their office, regard this as their own prerogative.
- Political decision-makers who do not share the value premises underlying the evaluative component of a TA study will not reject the TA results because of their cognitive content, but because of the implied political recommendations for action.
- In the context of political rationality, TA will only ever be used to the extent that it serves or can be made to serve political intentions. Consequently, there is a tendency to instrumentalize TA politically by using it to legitimize decisions instead of basing decisions on it (Mayntz 1983).

To summarize, it can be said that if TA is not to remain a purely academic exercise, then scientific research must always be related to the political process with its conflicts of interest and problems of consensus-building as well as to existing, restricted scopes of action.

2.3 Impact orientation in politics

As an institutional proposal, the TA concept makes demands on different social subsystems and has the function of linking the activities of these subsystems with one another:

- The scientific system has the task of drawing up analyses, forecasts and assessment perspectives that can be used to analyze and evaluate the consequences in an interdisciplinary manner;
- With the help of TA, policy should be placed on a scientific information basis in order to be able to act in an anticipatory and controlled manner;
- With the help of TA, the public, politics and science should be interlinked in such a way that the stakeholders and those affected by scientific and technological progress can reach a consensus on the goals of technological development.

At its core, the TA concept therefore has a scientific-analytical, a decision-related and an institutional consensus-generating component. In our context, we will focus solely on the problems of integrating TA into the political system.

A technology assessment that is intended to deliver decision-relevant results cannot be carried out solely as a purely scientific knowledge process. Carpenter refers to the two main components of TA as *impact analysis*, which focuses on recording the effects, and *policy analysis*, which first classifies the effects as undesirable or desirable in order to then formulate policy alternatives (Carpenter 1982).

Scientific investigation and political discussion must be related to each other in an interactive process in such a way that cooperation between the analysis team and political decision-makers arises as early as the problem definition stage and then subsequently during the formulation of policy alternatives. Ideally, the organization of the TA process should make it possible to link scientific research, public opinion and political decision-making. TA studies are thus located in the intermediate area of science and politics, which is neither adequately defined by the decisionist model of policy advice, in which scientists and politicians are separated, nor by the technocratic model, in which the political decision is replaced by scientific analysis. Instead, it is a decision-making process in which different interests are balanced and an attempt is made to reach consensus, both taking into account and drawing on research findings. TA does not so much establish direct decision-making concepts, but rather forms the intellectual basis for the conception, orientation and empirically based generalization of policy alternatives. It is not possible to deal in detail with the associated problems of a complex link between political decision-making and scientific analysis. For example, questions of the organization and cooperation of scientific experts, decision-makers and affected citizens would have to be discussed, or the question of participation and democratic control raised.

However, reference should be made to a structural change in politics that is associated with an orientation of political action toward consequences. By opening up the political decision-making process to a stronger future orientation, which is enforced by TA analyses, the certainty of decision-making in the political system itself is affected.

Three consequential problems of this orientation toward the future must be considered, which become characteristics of a policy oriented toward consequences and whose consequences are difficult to assess:

- With the help of TA, the success of a policy should be measured by its consequences. Since this impact test can be very risky for the political system

in view of the fact that changes in values and norms can never be ruled out, the obvious demand is to include the change in values in the calculation. However, the question then arises as to how diverse and in-depth a factual breakdown of the consequences to be considered can be without the decision-making process or the discussion of consequences being used to legitimize non-decisions.

This question involves both the unresolved problems of decision-making technology (how accurate and how realistic are impact forecasting and impact calculation?), and questions of political decision-making legitimacy. If the analysis shows that the probable social costs are greater than the expected benefits, should citizens take action and prevent the introduction of the technology in question?

- A consequential orientation can have a de-differentiating effect if the aspects to be considered are highly interdependent. With the possibly enormously increased variety of consequences and effects to be considered, the only way out may be to forcibly harmonize contradictory purposes and different orientations in order to establish a uniform standard of value. Closely related to this is another danger, which can be described as a subjectivization of the basis for decision-making. Since every consideration of consequences represents a selection, the selection criteria require justification: it therefore becomes clear that one could have used other criteria than those chosen. The burden of justifying the selections is therefore passed back to the political system. Looking at the political process within the TA paradigm, the paradoxical situation can arise that the only decisions that can be expected to be prevented are those that have demonstrably scandalous consequences, but that the consideration of consequences cannot provide a viable basis for fundamental "alternative courses of action."
- A third consideration relates to the legitimization mode. Since the social and political consequences can be broken down as far as desired, the discontinuations, reductions in vision and reductions must be justified when considering the consequences. As a result, there is a risk that the argumentation becomes circular: Politicians want to exonerate themselves legitimately by referring to consequences, but cannot refer to an authority – least of all to science – that can legitimize the discontinuation in the consideration of consequences, unless this discontinuation is dogmatically legitimized.

These three problems of an increasing focus on consequences in politics, namely the shifting of the test of political decisions into the future, the subjectivization of the basis for decision-making and the danger of a dogmatic conclusion to the

consideration of consequences, also address problems of the institutionalization of TA in the political process itself.

3. Institutionalization patterns of TA

In the more than twenty-year history of technology assessment, the most diverse ideas of TA have been tested in practice. It soon became apparent that an exclusive focus on the implementation of studies and their methodology limited technology assessment to an overly narrow management-oriented and technicist approach and completely excluded questions of citizen participation. It was not until the reorientation of TA philosophy at the beginning of the 1980s that TA was not only seen as a means of decision support, but – inspired by the institutiona-lization debate – the TA concept was also discussed in terms of its social objectives and uses. Three models emerged with regard to the definition of functions, which signify divergent objectives for technology assessment and also imply different institutionalization measures:

- the "instrumental model"
- the "elitist model"
- the "participative model"

These different conceptualizations of TA differ in the mediation between science, politics and the public, and thus indicate how the evaluation process is to be organized in society and how it is to develop procedurally.

The *instrumental variant* is characterized by the direct link between science and political decision-making processes. It is the original idea of Daddario's TA draft, which is ultimately based on an "instrumental model of action." As an element of political decision-making, TA is intended to increase political control potential on a scientific basis through the early identification, assessment and evaluation of the consequences of scientific and technological development and the determination of alternatives and options. The foresight of the political system should be increased through the institutionalization of technology assessment and thus enable a "preventive technology assessment." By defining and assessing the consequences at an early stage, technology policy decisions are to be placed on a secure foundation and become a mechanism for creating acceptance and legitimacy.

In this way, TA is intended to improve the effectiveness of political and administrative action by organizing available knowledge and broadening the basis for political decision-making through natural, technical and social science expertise.

TA means scientific methodology extended into politics and represents a step toward the "scientification" of politics. With the help of science, the political-administrative system attempts to overcome its constraints on action through new options and at the same time submits itself to a scientific, i.e., experimental paradigm when determining its strategies for action (Bechmann/Wingert 1981a).

TA remains as input into the decision-making processes in the existing decision-making structures and, depending on the intention, remains an information and control instrument of the legislature or an early warning instrument for "anticipatory consequence management" by recognizing the opportunities and risks of technical developments.

In this context, the public is only granted a passive role in which it is *informed* about the problems and consequences of the technology policy decisions made as part of a public dialog. Forms of this public participation can be seen in the "Technology Policy Dialogue" or "Citizens' Dialogue on Nuclear Energy," which was launched by the German government at the end of the 1970s. However, the intended mediation function between technology policy decisions, social values and interests remains "synthetic" here in that the public is ultimately not granted any real influence on the decisions. The significance of TA here is limited to a pure evaluation activity for the political-administrative system.

The main aim of the "*elitist model*" is to channel political and public discussion. The various models of the "Science Court" and the example of the "Royal Commission" point to the installation of an "arbitrator function" in the technology policy debate. The "notables" of these approaches attempt to provide the basis for defusing public controversies and for the evaluation of facts and decisions by determining "factual knowledge" and broad public reference. In this model, science has the most important function in the dispute over the direction of technological progress.

In addition to the traditional decision-making bodies such as the government, parliament and the courts, a new institution is to be created that is essentially staffed by renowned scientists who are to decide on questions of scientific and technological development in the manner of a court of law. In this way, scientific and technical problems are being removed from the political responsibility of democratic institutions and shifted to a body of experts that has scientific competence but is not appointed according to democratic principles. Ultimately, science sits in judgment of its own projects. The discourse on fundamental decisions on

social development is thus reduced to a small elite of "experts." In the true sense of the word, this suppresses the cause that gave rise to TA: namely the insight that the conflict over scientific and technological projects should be seen as part of a larger social restructuring process involving far-reaching cultural, social and political modernization. In these considerations, the public only has the passive role of observer, who then has to agree with the experts in their assessments.

The "*democratic model*" of an institutional orientation of TA fundamentally changes the constellation of science and politics by assigning the public a constitutive function in the evaluation of technology. Against the background of the conflicts surrounding technological development, TA is given the task of providing factual information about technology and its consequences on the one hand, and identifying and disclosing interests and affected parties in technological development on the other. In this conflict-oriented approach, TA supports the public "discourse" through scientific expertise, problem structuring and conflict transparency and thus expands social reflexivity. TA thus forms a decisive element in a conflict-oriented social learning process in which technical and economic feasibility and compatibility are communicated. This also provides the opportunity for a significant broadening of the basis of TA itself.

In this approach, explicit reference is made to the social conditionality of technological development and it becomes clear that social institutions require progressive supplementation and restructuring as a result of technological change.

4. Limits of instrumental reason

Two constitutive features of TA lie in the model of instrumental rationality and in the means/end scheme, as well as in the requirement to base decisions on their consequences and to use these as evaluation criteria for political measures: instrumental rationality and impact orientation. However, these have limits, which are also a challenge for TA.

It is part of the established program of critical discussions of TA to confront it with its own claims. In a bitingly ironic commentary, Ida Hoos complains that the analysis of institutional aspects of the decision-making process, originally the program of TA, was neglected in later analyses (Hoos 1979). Or Wynne, in an analysis rich in quotations, reproaches TA proponents for the fact that the TA concepts pursued to date contain a false understanding of social and, in particular, political processes, the core of which lies in a one-sided scientist

concept of rationality, so that TA can be recognized as no more than a "rhetoric of consensus politics" (Wynne 1975). To disavow scientific contributions to politics itself as a political game is often true to the factual role that science plays, but on the other hand it is also part of the criticism game. However, contributions based solely on criticism only take the necessary analyses further to a limited extent. It seems to make more sense to work out basic decision-making models and to ask how these can be reconciled with different political contexts (Bozeman/Rossini 1979). In the following, such an analysis, which would show the limits of instrumental rationality, for example by pointing out that the "rational actor model" can only be fitted into particular political contexts, will not be added. Rather, some fundamental arguments on the limits of instrumental rationality will be mentioned (Tribe 1973):

- There are inherent limits to instrumental rationality that have to do with the resolvability of a decision situation into a collection of alternatives, the differentiability and clear delimitation of these alternatives, and with the measurability and attributability of effects. This has often been described in the criticism of formal models, especially cost-benefit and related models.
- More fundamental is the objection that instrumental reason neglects process orientation in technology development. It is often not so much a matter of knowing the results and the effects, but of estimating the costs of the process itself and paying attention to the psychosocial and social dynamics that people's self-image experiences, or even suffers, in dealing with their technical artifacts. It is equally important not to know the values of the future in order to assess the possible effects of this anticipation in retrospect, but to examine how we can develop and set more appropriate values.
- In many respects, technological development does not consist in the choice of alternative means-ends relations, but rather technologies develop their own dynamic, against which ends and means can hardly be chosen. With some technologies (e.g., the seemingly possible biotechnical or asexual reproduction of humans or the biomedical perspectives of electrical stimulation and manipulation) that Tribe discusses, the question of the consequences simply becomes pointless because the integrity of the human being is directly affected. With regard to such technologies, there is only a moral and ethical answer.

It can also be seen as a merit of the TA discussion to bring such questions, as paradigmatically discussed by Tribe, into sharp focus without immediately demanding a solution technique or having one ready.

These three key arguments outline the limits of a program that is described and criticized in today's discussion as the concept of instrumental reason (Horkheimer 1967, Ullrich 1987). What is meant by this is that the Enlightenment concept of reason is reduced to the subjective moments of a pure means-ends relationship. According to this view, only the optimization of means in relation to the ends set by the subject is rational. Only this relation is accessible to the rationalization efforts of the individual. This understanding of reason and rationality corresponds to an understanding of politics and technology that sees politics as the authority that sets the binding ends, and technology as the authority that provides the means to realize the ends in the best possible way. Technology as an instrument and politics as a decisionist authority for the realization of values – this has been the secret paradigm of TA from the very beginning, and this idea still lives on today in the institutionalization debate (Dierkes 1985, Deutscher Bundestag 1986). This is not the place to repeat this criticism; instead, some comments should be made on how the dilemma of the instrumental understanding of TA can be resolved:

First of all, it must be made clear that an orientation toward consequences implies an orientation toward an uncertain future. Dealing with the control of consequences and the planning of consequences is known from the debate on planning optimism, and the TA movement could learn from this (Tenbruck 1972). At the same time, the concept of consequences implies the deliberate termination of the analysis. In no case can all consequences, secondary consequences or consequences of consequences be analyzed.

Consequential considerations are associated with selections and discontinuations. But how can these in turn be justified? If one considers that consequences are always artificially isolated aspects of a future reality, then the problem of justification shifts to the selection of relevant consequences on which consensus must first be reached (White 1986). Considerations of consequences thus inherently point to consensus strategies. In order to find such stop rules for the analysis, there are several possibilities, all of which, as far as can be seen, have already been practiced:

- The problem of justifying the selection can be left to the expert – with the consequence of delegitimizing the expert.
- The choice can be made from an ethical point of view – with the consequence of ethics becoming contingent.
- You can leave the choice to boredom – after the 50th study on forest dieback, society moves on to another topic.

- And you can try to organize a public discourse with the result that more nos are produced than yeses; i.e., in the end the dissent is greater than the consensus.

In other words, the choice of consequences, but also the termination of the causality of consequences and their attribution, *presents itself as a decision-making problem that must be socially clarified in some form.* Since Western rationalization was understood by Max Weber as a cultural implementation of rationality of purpose, and it is precisely this rationality of purpose that has pursued both the disenchantment of the world with private purposes and values as the ultimate instances of action, only to then itself fall into the reputation of the ideological, it has become increasingly difficult to justify general normative orientations. Incidentally, an ethics of the technical also suffers from this dilemma (Lenk/Ropohl 1987).

As an alternative to this model of means-ends rationality, which is recognizable in its limits, forms of argumentative justification of action are sought today for the area of dealing with people, which are supposed to have their rationality in the fact that they must convince everyone under extreme conditions ("freedom from domination," unlimited time, equal opportunity socialization). The idealized boundary conditions have the same function here as the optimization conditions of the calculations of the means-ends scheme: they steer the rationality model into a marginal position that can never be achieved in reality, but which, it is demanded, should be kept in mind with an oblique view (Habermas 1983, 1985). The classical rationality criteria referred to the means-ends relationship and defined their demands for optimization in relation to this. To date, TA has also adhered to these basic concepts – without ever being able to achieve them. Similarly, orientation, justification and the achievement of intersubjectively acceptable consensus are likely to fail because rationality is understood as a regulative idea. We know that regulative ideas take no account of time and therefore fail in the face of reality. The resources of time, money and personnel form the limits both for a rationality that is oriented toward optimization goals and for a rationality that is oriented toward justification structures. The need to come to terms with rationality barriers in the decision-making process has led to the search for weakened rationality. The Arrow theorem, the prisoner's dilemma, or Herbert A. Simon's criticism of the optimality maxim have led to a new view of rational decisions (Elster 1987).

The core of these theoretical efforts is the attempt to find useful decision rules that take into account the "constraints" of the decision instead of optimal rationality criteria. Three consequences can be drawn from this for TA analyses.

Firstly, if the termination of the consequence analysis is to be rational to a limited extent without ignoring the restrictions, then the uncertainty as to which consequences are relevant can be reduced by means of tests. The problem of rationality is partially reformulated here as a problem of the validity of tests or other diagnostic instruments. Or secondly, the solution may consist of a biased assessment of the risk of error. The main aim is to avoid the worst consequences. The concept of the worst-case scenario is an example of this. Thirdly, hard and soft selection criteria can be combined. This would mean a detailed selection of possible consequences, followed by a more limited investigation of their effects.

All three strategies have the advantage that they can also be used in combination and provide a rational connection. The process of impact analysis can be interrupted without a final judgment having to be made. TA then presents itself as an iterative process in which the questions of consequences can be raised and discussed again and again. Nevertheless, this type of consideration gives rise to situation-specific criteria of usefulness that need not deny their social constitution. *This process could be called rationality with explicit rules of error.*

5. Concluding remarks

The political, but also the scientific discussions about the possible institutionalization of a TA system have shown that both the scientific and the political resources are not yet available to use TA in its comprehensive claim. In this sense, TA studies initially have the task of sensitizing political decision-makers and the public. As an element of a social learning process, albeit one fraught with conflict, they help to reveal the problems and lines of conflict in technological projects. In this respect, their value may initially lie more in raising critical awareness than in contributing directly to decision-making.

However, it seems clear that a new arrangement between scientific analysis and political-public discussion must be found in view of the increasing risks of modernization. What the specific forms of social organization might look like in each case depends on the political and social balance of power within which the development of technology takes place. One thing the technology debate has made clear is that technology is a social project that is subject to the public negotiation process of social actors.

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