4.
TA as a theoretical approach – the action-theoretical and system-analytical dimension

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Technology assessment: A strategic framework for the analysis and evaluation of technologies

Preliminary remarks

In 1966, the Subcommittee on Science, Research, and Development of the House of Representatives of the U.S. Congress published a report on the side effects of technological innovations, which included a call for the establishment of an "early warning system" to detect negative and positive consequences of technological applications (United States Congress 1966). The term "technology assessment" was probably used officially for the first time in this report. Since then, the methodology, practice, and institutionalization of technology assessment have become more specific and differentiated in terms of objectives, basic concepts, methodological instruments and institutionalization options (Porter et al. 1980). A series of exemplary TA case studies was carried out – in many cases on behalf of the National Science Foundation (Jones 1973) – and with the Office of Technology Assessment of Congress established by the Technology Assessment Act of 1972, a TA institution was created that has remained unique in terms of its size and institutional structure to this day.

After a short time, the "technology assessment movement" spread to other countries, especially to the industrially highly developed countries, and increasingly influenced the research and technology policy debate there (Coates/Fabian 1982; Böhret/Franz 1982; Leyten/Smits 1987; Smits 1987).

1. Basic concerns of the TA concept

In the Federal Republic of Germany, the term "Technologiefolgen-Abschätzung" or "Technikfolgen-Abschätzung" has now become widely accepted as a translation of technology assessment, at least among "TA practitioners." This choice of words is not a particularly happy one, because it could encourage the opinion that it is merely a matter of determining – as quantitatively as possible – the individual consequences of technology applications, and in particular not of evaluating them as a prerequisite for an overall assessment of the technology or technology

application under consideration and for comparison with alternatives. However, such an idea would be completely inaccurate: technology assessment goes far beyond the identification and quantification of singular consequential aspects of the use of technology. Roughly speaking, TA aims to:

- Systematically research and evaluate the conditions and (potential) effects of the introduction and (widespread) use of techniques,
- Identify and analyze areas of social conflict that can arise through the use of technology, and
- Identify and review possible courses of action for improving the technology under consideration or its application modalities (policy analysis).[1]

In terms of its origin and concept, TA is therefore an analysis and evaluation approach with regard to the prerequisites and potential consequences of the social use of technologies. Criticism of its technology-centeredness on the one hand and the "consequences" fixation on the other are therefore certainly futile at the conceptual level. The long-standing *practice* of TA, however, will have to face the accusation that it has neglected the social conditions of technology use in particular, and that by ignoring alternative design options, alternative technologies or non-technical solution concepts, it has itself caused the criticism of technology determinism.

In the German-language literature, technology assessment is often referred to as a "procedure." This is misleading insofar as there is no binding, routine and generally applicable procedure for TA studies, nor can there be in view of the variety of specific issues relating to the very different technologies with which TA analysts are confronted.[2] Rather, TA should be understood as a "strategic framework concept." This concept can be related to others with a similar general objective – increasing the "awareness of consequences" of political and economic

1 In order to prevent the possible misunderstanding described above, the term "technology evaluation" (Technikbewertung) or "technology impact evaluation" (Technikfolgenbewertung) is sometimes preferred – but this causes irritation of a different kind.

2 Vary T. Coates formulates this as follows: "Technology Assessment [...] now is recognized as not one research algorithm or model but as a varied palette of analytical and speculative techniques used in support of public formulation and strategic planning" (Coates 1983). For Joseph F. Coates, who worked for a long time at the National Science Foundation and the Office of Technology Assessment of the U.S. Congress, TA is "more an art form which must be actively created and framed to fit the individual issue or problem being assessed" (Coates 1974).

action – such as so-called "accompanying technology research."[3] Both technology assessment and accompanying technology research (Bechmann/Wingert 1981) aim to address and solve the problem of controlling the consequences of actions. They differ in their basic strategic conception, roughly outlined here, as follows:

- TA should present the available knowledge (with evidence of knowledge gaps) about the realization conditions and effects of technologies in as anticipatory a manner as possible, in a generally comprehensive overall balance and in a decision-oriented manner. The approach is "cross-sectional," so to speak.
- The idea of accompanying research, on the other hand, is primarily to shape the process of realizing an innovation in accordance with criticisms after the fundamental decisions on the use of the technology have already been made. The approach is "longitudinal", so to speak.

From a comparative perspective, the concept of the environmental impact assessment (EIA) can also be considered.

Both TA and EIA are a form of timely action and decision planning in view of possible consequences. Both are also prevention-oriented, aim to analyze consequences as comprehensively as possible and are committed to the idea of participation. The differences between the two approaches lie in the following aspects, among others:

> TA is a medium for consultation between science and politics in the course of preparing political discussion processes and measures. The participation of affected and interested groups is a non-binding component of the overall process.
>
> EIA is integrated into the formal administrative procedure and serves to expand the planning concept and the criteria of the planning administration with the aim of environmental precaution. The type, scope and legal quality of participation is prescribed in a procedurally binding manner.

The implementation of concrete TA studies requires the detailed, case-related fulfillment of the framework concept, i.e., the development of a pragmatic strategy adequate to the respective question (e.g., Coenen et al. 1988, p. 3ff.). In this context, "flow charts" and "checklists," as offered in the TA literature (Jones 1971),

3 Other examples include evaluation research, which is essentially an ex-post impact analysis designed to provide information on the effectiveness of measures taken, as well as indications for subsequent impact management and improved future planning and decisions, and risk assessment (identification, estimation and evaluation of risks).

can only provide a limited amount of initial help in the conception phase of TA projects.

2. Pros and cons in the debate on TA

There are many good arguments which, as one might think at first glance, should make TA appear to be a generally plausible and attractive proposition, the realization of which promises considerable benefits for society as a whole. These arguments relate above all to the recognizably increasing threat to many areas of society and the natural environment from the unforeseen side- or delayed effects of technologies with considerable "primary benefits," to the growing complexity and magnitude of new technologies with increasingly difficult to understand and possibly irreversible "impact chains," and to the irrefutable need to conserve increasingly scarce natural resources (Krupp 1990). The fact that the public debate on technology assessment has nevertheless been controversial from the outset can initially be explained by the different interests of the social groups concerned.

For example, industry, but also government agencies, have frequently expressed the fear that a broad application of the technology assessment concept would inhibit technical progress – and thus also economic growth – and ultimately lead to a "technology arrestment" (Coates 1971; Green 1972): Innovators would be deterred, technical developments and applications would be hindered and blocked, and by detailing long-term, usually quite improbable consequences, TA would create a climate of fear and only create the problems that would cause sections of the population to refuse to accept it. The practice of technology assessment to date does not confirm this fear, at least in that only in exceptional cases have technology projects been completely blocked due to technology assessment analyses; on the contrary, there is much to suggest that such analyses tend to promote the process of technical progress, for example by encouraging the development and use of improved technical variants and alternatives. The aim of TA is not to hinder, but to "shape" socio-technical systems in a reflective manner. In fact, one of the main tasks of TA is to draw attention to the potential risks of using technologies that are usually ignored in conventional planning and evaluation procedures, e.g., investment calculations or market analyses. This is based on the conviction that ignoring or concealing possible disadvantages and dangers of a technology ultimately has a far more negative impact on public acceptance than disclosing potential threats at an early stage, which will be uncovered sooner or later.

What the term "impact assessment" may suggest semantically is not actually its aim: the concept is not designed to eliminate and compensate for problem-generating development and use of technology. Rather, it is about the *ex-ante* opportunity to set a course that *avoids* problems. However, in view of the decentralized, pluralistic structure of technology producers, this can only be done by the state and politicians within the framework and with the intensity of intervention that can be considered enforceable and acceptable from a regulatory point of view.

While critics, especially from industry (Meier 1987; see also Rautenberg 1989), see TA as a kind of "obstruction strategy," other interest groups often make the opposite accusation, namely that technology assessment is nothing more than a subtle "enforcement strategy" for technical developments and projects (Coates 1973; Büllingen 1984). It is precisely this accusation that underlines the fundamental importance of some of the demands that have been made with regard to the organization of TA processes (Paschen et al. 1978), namely:

- to make such processes transparent and verifiable at every step due to the large number of assumptions and value judgments to be made,
- to ensure the active participation of the groups most affected by the use of technology, because the lack of genuine opportunities for such groups to participate increases the risk of manipulation and the one-sided favoring of particular interests,
- to inform the public about interim results and decisions as well as their justification during the course of (important) TA investigations.

In this context, the accusation raised in some developing countries that efforts to harness the TA concept for the purposes of development policy should be seen as an attempt by highly industrialized countries to perpetuate their dominance in the field of state-of-the-art large-scale technologies should not go unmentioned. This accusation probably has its origins in the fact that in the discussion about the application of the TA concept for the interests of developing countries there is a close connection between technology assessment and the problem of selecting "appropriate" technologies, and the latter are only "second choice" technologies in the eyes of some politicians from developing countries (United Nations 1979; Boroush et al. 1980).

The character of TA as an element of decision-making processes gives rise to a further point of contention. In order to be effective in the sense of implementing the results of an analysis in political and – depending on the addressee – also corporate measures, the TA function must be integrated into the decision-making

process in an appropriate manner, i.e., it must be organized and institutionalized to some extent. In the Federal Republic of Germany in particular, this problem of institutionalization has been a controversial ongoing topic in the "technology assessment debate", especially in connection with the demand for the creation of a TA institution at the German Bundestag.

However, if science – in the form of TA – is placed as an element of political (or even economic) decision-making processes, the question of the ultimately decisive opinion leadership and decision-making authority in such collaborations arises almost as a matter of course. We now know from rich experience that competitive relationships develop in the joint processing of a problem area. In general terms, these are such that, due to the very different characteristics and functions that distinguish science on the one hand and politics and business on the other, efficient communication between science and the application system is extremely difficult to achieve, as there are "hardly any clear point-by-point correlations: neither in terms of time nor in terms of subject matter, nor with regard to partners and role contexts" (Luhmann 1977, p. 30).

Although, in our opinion, there is no alternative to undergoing the efforts of this communication and cooperation, Luhmann's assessment that it makes little sense "to expect communicative interaction to resolve differences through consensus in the true and the good" (Luhmann 1977, p. 31; cf. Petermann 1988) is nevertheless important.

The quality of TA practice to date is also controversial. A very pointed criticism of practical TA work is contained in a study presented by the OECD in 1978, in which 15 case studies were analyzed that had been made available to the OECD Secretariat by the member countries as representative of work in the field of technology assessment (OECD 1978). Although these case studies were completed in 1974 or earlier, the OECD's findings are still largely valid today (Jochem 1989, 1990; OECD 1983):

- Only very few of the studies reviewed undertook a systematic identification of impacts and a "homogeneous assessment" of all impact areas. The selection of impact areas is highly intuitive, often determined by personal preferences or access to useful data.
- Very few studies would take into account the interests and problems of those affected by the use of technology.
- Only inadequate attempts are made to forecast possible future changes in the environment in which technology is used, i.e., in social, political and economic trends.

A set of "methodological guidelines" developed by the OECD itself and published in 1975 (OECD 1975), served as a benchmark for evaluation, describing a kind of "ideal" of technology assessment. Apart from the fact that studies from the early days of technology assessment can hardly be expected to meet the expectations of "TA purists," the fundamental question must be asked as to whether TA analyses as a complete implementation of desirable maxims represent a practically feasible possibility at all. This question is explored further in the following sections.

Excessive demands on TA practice, i.e., the processing of TA assignments resulting directly from the "ideal concept," are described and discussed, and problems associated with this concept in the implementation of TA results in the world of action of the addressees are also considered.

3. The "ideal concept"

Such an ideal concept of TA is based on a series of postulates,[4] which have already been mentioned. These postulates will be presented in more detail in this section.

- *TA analyses should anticipate the realization conditions and potential consequences of the use of technologies and thus serve as an "early warning" (postulate 1).*
  From the very beginning, the main concern of technology assessment has been to identify and weigh up the realization conditions and potential consequences of the introduction and application of new technologies, or technologies still under development, or the increased or modified application of known technologies[5] before a situation is created (e.g., through extensive investments) in which the freedom of decision regarding the use of these technologies is already severely impaired ("constraints"). "Early warning" or "early detection" is, as it were, the programmatic core of at least the so-called "technology-induced" TA studies, in which a specific technology – still under development or testing, or already in use – forms the starting point for the

4 Cf., for example, Coates 1974; Deutscher Bundestag 1986; Kawamura et al. 1979; OECD 1975; OECD 1978; Paschen et al. 1978; Porter et al. 1980.

5 Many advocates of technology assessment also consider "social technologies" – such as various forms of organization, standards, co-determination models and forms of taxation – which can have far-reaching effects in many areas of society, to be part of the scope of technology assessment.

various analysis steps:[6] Negative consequences are to be avoided from the outset, or at least limited.

- *The range of impacts to be identified, assessed, and evaluated in TA analyses should be "comprehensive" (postulate 2).*
  It is required that particular emphasis be placed on the analysis of
  - unintended (side) effects of the use of technologies,
  - indirect effects, which often occur with a long delay (second and higher order effects),
  - cumulative and synergetic effects,
  - institutional and social consequences (effects on social structures, socio-cultural values, socio-political systems, etc.),
  - (re)effects of social developments on technological developments (consideration of the social environment of the use of technology),
  - impact categories that cannot be quantified (or at least not in a meaningful way),
  - without neglecting the planned, primary, economic-technical, directly quantifiable effects.
  - *The technology to be assessed should also not be considered in isolation.*
  - This means that
  - important technical variants (system alternatives) of the technology under consideration, and
  - technologies complementary to the "main technology" (example: uranium enrichment plants as a complementary technology to nuclear power plants),
  - should be included in the investigation.
  - In addition, the short- and long-term interactions between the technology to be assessed and competing technologies must be taken into account. In all cases – depending on the time horizon of the study – future

6 *"Technology-induced" TA analyses* deal with the problem of the use of a technology with regard to the consequences for the environment and society in the context of a wide range of proven or potential applications. In contrast, *"problem-induced" TA studies* aim to analyze alternative solutions to an acute or foreseeable (economic, ecological, resource-related, social) problem. These are often problems that are (co-) caused by technologies in an "interplay" that is often difficult to understand – or where there is at least a suspicion of this: It is always about problems where there is an expectation that technology can make a significant contribution to solving them. This distinction should be handled with caution – even for analytical purposes. Technology-induced TA is hardly conceivable without a systematic reference to problems and needs.

technical developments in the area under consideration must be taken into account as far as possible.

- *TA analyses should be "decision-oriented" (postulate 3).* In other words, they are intended to increase the level of reflection and rationality of decision-makers by incorporating problem-oriented knowledge about technical developments and programs into decision-making processes. The aim is not only to contribute to the preparation of decisions that have already been recognized as more or less urgent, but also, for example, to clarify whether there is a need for decision-making with regard to a new or developing technology, or with regard to an emerging economic, ecological, resource-related, or social problem.
  Closely related to the postulate of "decision orientation" is the requirement that TA studies – over and above impact analysis and assessment – *should identify and review alternative measures or packages of measures (options for action)* in a "constructive" part, through which the technologies under consideration or their application modalities can be improved in such a way that overall fewer negative and/or stronger positive effects can be expected. Whether the explicit formulation of recommendations for the implementation of *very specific* measures is still one of the tasks of a TA team is judged differently; this certainly depends not least on the interests of the respective client and the self-image of the TA analysts. Examples of such options for action (Coates 1971) are:

  — Implementation of a monitoring or surveillance program parallel to the introduction of the technology (in the event of great uncertainty about the effects of a technology application and the resulting areas of social conflict);
  — Staging of evaluation measures or accompanying research, creation of committees with a monitoring, approval or control function;
  — Legal measures to prevent or tax incentives to promote specific applications of a technology;
  — Changes in institutional structures associated with the introduction of the analyzed technology;
  — In extreme cases: abandonment of a project or a technology, if necessary testing of completely different solutions than those originally planned (so-called macro-alternatives).

- *Technology assessment should be "participatory," not "elitist" (postulate 4).* This means that, despite the major organizational and communication problems,

the aim is to achieve broad participation by the social groups affected by the consequences of technology use.

Some of the reasons given for this demand are:

- The utilization of the situation-specific knowledge of those affected is an indispensable prerequisite for realistic TA analyses.
- Some effects of a technology application are often only taken seriously when a group of people affected insists on them being discussed.
- The danger of manipulation by specific interests can best be countered by the active participation of many affected individuals and groups.
- More recently, there has also been a widespread expectation that consensus between proponents and critics of a particular way of using technology could be achieved or developed through participatory procedures within a TA process.

- The results of TA analyses are highly dependent on the subjective assessments of TA analysts and their clients; value judgments must be made at every stage of the TA analysis process. The increasing realization of the decisive role that interests and standards play in TA as a "value-sensitive" procedure (Deutscher Bundestag 1986) results in the *demand for transparency, traceability and verifiability of TA processes: Assumptions and value judgments and their justification should be disclosed (postulate 5).*

4. Problematization of the "ideal concept"

The "ideal concept" described above, with its plethora of demands, leads in most cases to TA practice being overwhelmed. This is particularly true when it comes to the (technology- and problem-induced) impact assessment and evaluation of far-reaching technologies (e.g., energy technologies, transportation technologies, information technologies, new biotechnologies). Such technologies do not have the "machine character" of an artifact, but are networked with other technical and social systems and are diffuse in a way that makes anticipatory analysis extremely difficult. Programmatic overload is also obvious if one takes the view that an assessment and evaluation process for a far-reaching technology or a serious acute or foreseeable social problem can be "completed" by a *single* study comprehensively designed according to the requirements of the "ideal concept."

Aspects of this problem are illustrated below using the example of postulates 1 and 2. The aim is also to provide indications of conceivable ways out of the difficulties in applying the "ideal concept."

With the firm claim to analyze the dangers and risks that may be associated with the development and use of technologies *at the earliest possible stage (postulate 1),* TA has taken on enormous theoretical, methodological and data problems. A TA study carried out with regard to this claim would require information to be available on the future "need" or demand for the technology or on the future scope of technology use, on "reinforcing" or "disruptive" developments in the environment of the expanding technology, on its further development and its alternatives, on the long-term ecological and social effects of technology use, and on future values as a prerequisite for weighting and evaluating subsequent effects.

These and similar problems in the development of plausible statements about possible futures appear difficult to solve, if not impossible – especially if one expects such statements to have the status of exact, determinative "forecasts." For example, some consequences are only assessed as harmful over the course of time with increasing use of the technology and *growing awareness of the problem*. Particularly in the diffusion phase, new problems can always arise that are "unforeseeable." It is not surprising that there are those who declare that TA has failed as an attempt to create an "early warning system."

Many TA analysts now *see* technology assessment as a *"normative instrument"* whose task is to design plausible – or even desirable – alternative futures (scenarios) and to describe pathways (options, measures) and analyze them in terms of the conditions and consequences with which these futures can be achieved.

One possible manifestation of such an approach is a TA study by the Department of Applied Systems Analysis at the Karlsruhe Nuclear Research Centre, which looked at the technical possibilities, implementation conditions and consequences of increased use of hard coal for oil substitution in the Federal Republic of Germany (Coenen 1985). The study was based on the assumption that a proportion of mineral oil *should* be replaced by German hard coal. Accordingly, alternative scenarios were designed in which this goal is achieved, using different technical methods (electricity generation, combustion, gasification and liquefaction). The various options were then analyzed and evaluated with regard to various prerequisites and consequences. The result is well-founded answers to questions such as: If option or strategy X is chosen, what consequences can be expected – given defined framework conditions – and what preconditions must be met?

Of course, even with approaches that are "normative" in this sense, the "forecasting burden" of technology assessment remains high. The assumptions made must be based on "forward-looking" information, i.e., they must not be completely arbitrary. Above all, however, the problem remains of estimating (and evaluating) the possible future consequences resulting from the assumptions or the options based on them, in a situation of largely unexplored cause-and-effect relationships. There is an urgent need to intensify impact research, particularly in the area of the ecological and social effects of the use of technology, in order to improve the information base for balancing and evaluating TA analyses.

It is now widely accepted among TA analysts that a significant reduction in the prognostic burden can only be achieved if TA investigations are not conceived as a "one-off affair," but as a sequence of repeated analyses and assessments – as a *process*, so to speak – at least when it comes to the development and use of very far-reaching techniques. After an initial "TA round," further analyses should be carried out as necessary during the development and application of a technology in order to check whether an originally positive assessment may no longer be justified, and which – originally unrecognized or misjudged – negative consequences are becoming more significant. A continuous technology assessment in the sense of "monitoring" developments and development opportunities is also conceivable. Such an approach enables better adaptation to political decision-making processes. The idea that political decisions on technologies are finally made at a specific point in time on the basis of a one-off comprehensive assessment is quite unrealistic.

However, the "process approach" also harbors risks that need to be considered. For example:

- The "strategic structure" of the TA study can be jeopardized (one gets lost in an increasingly impenetrable thicket of detailed information and in the analysis of ever new options);
- There is a risk of losing the overall context, especially if the process-like implementation also implies splitting into partial studies;
- Fundamental decision-making options can be lost in the sense that perhaps only relatively insignificant modifications to the technology under consideration or its application modalities are possible. The concept of flexibility or reversibility plays a role here; it is very much a question of the extent to which it is realistic to assume that the process of introduction and diffusion is reversible in the case of large technical systems or other long-range technologies, for example.

The – not even complete – list of requirements drawn up to concretize *postulate 2* should make it clear that "comprehensive" technology assessments in this sense will usually be unfeasible for practical reasons alone (time and resources required). Fixating on such generally unfulfillable maximum requirements can only be detrimental to the use of TA in concrete decision-making processes.

In this context, a comment made by John H. Gibbons, Director of the Office of Technology Assessment at the U.S. Congress, at a symposium held in 1982 on the "Role of Technology Assessment in the Decision-Making Process" (Umweltbundesamt 1983) is revealing. With regard to the interest of the addressees of TA studies in "comprehensive" analyses, Gibbons says that such studies – assuming they were methodologically possible and could be carried out by the OTA – would find few takers among the political decision-makers for whom the OTA works. The U.S. Congress prepares its decisions in subcommittees; these need TA analyses that focus on a specific area but do not ignore the broader implications of the problem in question. The OTA always tries to keep the "customer" – his needs and constraints – in mind.

As informative as such references may be for the design and communication of TA and for improving the interaction between TA users and TA producers, it is important to warn against the latter orienting themselves exclusively to political and other user requirements and reducing the demands of the TA concept too much. If the criterion of *comprehensive* analysis of a complex object of knowledge were to be abandoned without further ado, TA could easily lose its guiding effect and run the risk of losing its profile.

Nevertheless, pragmatic variants must be sought. One way out of the difficulties associated with postulate 2 is offered by the concept of *complementary* partial analyses, which can be imagined as follows:

Step 1: Problem analysis ("Mini-TA") with the following characteristics:

- less "depth" than a comprehensively designed TA analysis,
- partly only qualitative consideration,
- obtaining a preliminary overview of important impact areas and implementation problems,
- identification of "dominant" areas and those particularly "in need of analysis."

Step 2: Assignment of "partial" TA studies for the areas assessed as dominant.

Step 3: Implementation of such partial studies by institutes that have special expertise (e.g., better access to data).

Step 4: Assessment of the results; examination of whether further studies need to be carried out; integration into an "overall picture."

The individual partial analyses carried out on a specific topic must of course be coordinated and agreed in terms of content from the awarding of the contract to the evaluation, which also requires a degree of institutional support. If coordination and harmonization do not work then there is a risk, for example, that important "trade-offs" remain unrecognized (e.g., between the economy and ecology).

On the implementation side, the broad use of this concept requires a "network" of interdisciplinary working groups that cover the various areas of technology and can be commissioned to carry out (partial) TA analyses. Ensuring institutional continuity, but above all the scientific independence and neutrality of such TA groups, is a prerequisite for the high quality of TA studies and for the credibility of TA results as an information basis for decision-making processes. The demand for continuity of TA groups is of course not intended to rule out the possibility of forming temporary ad hoc groups, e.g., parliamentary commissions of inquiry, for specific TA problems.

Such a decentralized network should involve not only expert groups from the "established" research institutions, but also institutions that see themselves as "alternative" and/or pursue new and unconventional topics and methods.

If we now transfer the idea of complementary partial analyses from the level of individual TA processes to that of TA activities as a whole, this opens up the possibility of developing a strategy for the practical support of TA potential:

The informative value and practical effectiveness of individual TA projects could be increased by integrating them into a network of parallel TA projects – on a specific technology or a specific problem. In this way, complementary theoretical approaches and methods and the linking of selectively unearthed insights in a network of TA processes could constitute a broader spectrum of insights, and an approximation to the fundamentally far-reaching cognitive interest of the TA concept could be achieved. If such a network is not only synchronous, but also diachronic, these positive aspects can be further strengthened (Deutscher Bundestag 1986, p. 12).

The development of such a structured practice of TA activities with the aim of broadening the information base on socio-technical processes, increasing the

informative value of analyses, and enriching the range of possible options, would have to be institutionally and procedurally underpinned by the establishment and expansion of the network of capacities in research and advisory institutions already outlined, which are familiar with the specific procedures and information requirements of technology policy decision-making processes (Paschen et al. 1981, p. 65).

5. The problem of implementing TA results

The implementation or application of new knowledge is a constant problem for any kind of application-oriented research. Implementation deficits have always been deplored:

- between science and industry (innovation deficits, technology transfer problems),
- in the scientific system itself between basic research, applied research and development, but also between the individual scientific disciplines,
- between science and the political system in the broadest sense (legislature, executive, social interest groups).

This is no different with TA, although this type of research tends to focus less on the explanation of phenomena and more on the provision of knowledge for action, and must strive to include decision-making contexts in the analysis and thus overcome the barriers between the scientific system and the political system or the economic system (cf. postulate 3).

One reason for the implementation deficits of TA studies may initially lie in the *complexity* of the object of knowledge. The correspondingly necessary comprehensive analysis of diverse consequences can significantly strain the user's willingness to perceive and therefore lead to selective perception. The – ideally interdisciplinary – analysis of complex impact dimensions may only generate a moderate response and limited understanding on the part of the addressee – due to sectoral expertise and, as a rule, specialized disciplinary training.

In addition, at the macro level, decision-making processes in politics are generally driven simultaneously by a large number of fragmented units organized according to the division of labor, such as ministries, departments, committees, etc.

One of the main reasons for implementation deficits is probably that – as the discussion of postulates 1 and 2 in the previous section has shown – the results

of such studies are highly *hypothetical in nature* and are particularly fraught *with uncertainties* due to the concept.

Although the treatment of uncertain future developments by TA is valued and desired by potential users, the associated *deficits in certain knowledge* reduce the acceptance of the results. No TA process, no matter how sophisticated its mathematical forecasting models, can rule out uncertainties in statements about the future. This uncertainty, which is primarily due to the nature of the object of knowledge to which TA refers, entails a lack of certainty, which can lead to great skepticism in the reception of the results (Mayntz 1980, p. 313; Hammond et al. 1983, p. 294ff.).

In view of the dilemmas in the analysis and assessment of consequences, which can hardly be resolved, the appropriate path to more open-minded communication about possible futures with uncertain knowledge would not be a mere call for more research and greater certainty in decision-making. Rather, a modification of the "political decision-making culture" (Ewers 1990, p. 156) should be sought while partially renouncing the standards of scientific certainty of knowledge.

Another closely related reason for implementation problems, is that *normative aspects and value-sensitive strategic considerations* decisively determine the framework of every TA study and the implementation of the individual analysis steps (cf. postulate 5). However, the respective normative settings do not necessarily have to be shared by all potential users of the TA analysis. Even if it were possible to make them sufficiently and comprehensibly transparent, it could not be ruled out that they collide with those of the users. Confronted with different interests, values and preference structures in society, TA analyses run the risk – due to their normative character – of being perceived as possible triggers or amplifiers of conflict processes in socio-political disputes. It is possible that the controversy over values and norms then overlays the discussion of the analytical components of the TA process in a dysfunctional way (a discourse on this is actually desirable).

The *discrepancy between scientific (substantive) and political rationality* can be seen as another important reason why the actual contribution of TA – as well as other types of policy advice research – to shaping political decisions usually falls short of expectations (or fears) (Weiss 1978; Mayntz 1986).

This discrepancy – as the difference between two "ideal types" – can initially be described as one between two different world views.

Scientific approaches, in particular in social science, attempt to "explain the world" and operate with basic theoretical assumptions and a specific set of me-

thods that capture reality in categories that tend to be alien to the approaches and questions of practice. This difference[7] can also be understood as a competition between "lay images" and scientific world views, between everyday knowledge and scientific knowledge, which leads, for example, to controversies about which problem situations are considered worthy of investigation and in what order, and how they should be treated (Nowotny 1975, p. 449ff.).

Furthermore, even with a reflected application orientation of scientific analysis, a difference remains between the *thematization of* political options for action through technology assessment and *political action* as a search for consensus and the securing of power. Politics as a practice is subject to specific constraints such as the imperative to gain and maintain power, the need for tactical negotiation processes and compromise building, and the pressure to decide and act within a tight timeframe. All of this results in a narrow perception of the knowledge provided and its often tactically motivated use.

> Policy-makers for their part are interested not only in the application of research evidence to public decisions but also in representing interests and values, reconciling differences, and reaching compromises that maintain the stability of the system. Theirs is political rationality rather than scientific rationality. They may neglect research in their service of other functions, but, from their point of view, the use of research is not necessarily the highest good (Weiss 1978, p. 61).

Accordingly, politics must

> [...] refrain from such enlightenment [...] whose *consequences of action* would overstretch the institutional framework of politics and invalidate the interpretations and premises built into this framework" (Offe 1977, p. 323; emphasis added by the authors).

6. Concluding remarks

If the areas characterized in this way cooperate with each other, communication difficulties and a tendency toward conflict cannot be ruled out. However, the

7 The discrepancy between the two world views also manifests itself as a problem of mediation: If scientific knowledge and practical knowledge of action were identical in terms of their structures and elements, only theoretical propositions would have to be transformed into prescriptive propositions for the purpose of transferring science into practice. Since the two forms of knowledge are not identical, this solution perspective is fundamentally obstructed (Neidhart 1970, p. 332).

conclusion cannot be that TA has to adapt to the patterns of perceptions and possibilities for action in politics through "mimetic" efforts.

Attempts to resolve difficulties and improve the consultation process, which is jointly supported by science and politics, will only be successful if the difference between the two players is fundamentally recognized and respected. Nor should it be assumed that the (alleged) substantive rationality of science should be ascribed a higher dignity. A functional interlinking of analysis and evaluation processes will lead to a better integration of both sides in this process, if the respective (relative) autonomy and profile as well as the advantages of specialization are retained – and used in a reflected manner.

From this perspective, however, it is not enough to improve *procedures*. Rather, it is also necessary to further penetrate the relationship between science and policy theoretically, and at the same time to broaden the empirical basis for its assessment and for targeted improvements. Evaluations of the use of TA should be systematically continued and continuously supplemented. It is true here – as for advisory relationships in general – that they have by no means been sufficiently researched. This applies to scientific and epistemological as well as organizational-sociological and socio-psychological aspects of the utilization process, whose lack of "intensive observation" (Rosenmayr 1977, p. 36) is *one* cause of implementation difficulties (Petermann 1986).

Influenced by multiple context variables, the advisory situation in TA processes is an unstable structure. In order not to stop at a mere organizational "intermingling of science and politics" (Ronge/Schmieg 1973, p. 57), but at least to achieve an "institutionalization of reliable environmental sensitivity" (Scharpf 1973, p. 80), the conditions of advisory situations must be consciously analyzed and constantly improved. It should be noted, however, that the fundamental difference between science and politics cannot – and should not – be eliminated.

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