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Away from TA – but where to?

Preliminary remarks: The TA debate between continuity and innovation

The 1980s reinvented the criticism of the paradigm of technology assessment (TA). The conceptual problems and practical deficits that had already been criticized in the 1970s have been reactivated and presented, verbally revamped, as a reckoning with "consequence-free impact research" (Langenheder 1986), "first-generation TA," or "reactive TA."[1]

In most cases, the step toward the "better" is also recommended: "innovative technology assessment" (Ropohl 1985) is launched, TA for the new generation (Spinner 1989) is raised on the shield, "constructive TA" (Rip/van den Belt 1986)

1 A few notes on the characterization (of a critique) of critique:
It is often not clear what the object of criticism actually is: In Spinner's case, Hans Jonas' philosophy of technology is TA (Spinner 1989)!
Too little distinction is made between concept and practice: The criticism that claims that TA is "reactive" in concept does not take note of the concept with its principles ("*early* warning"/"timeliness").
Deficiencies are attributed to the concept (or practice) which are far more likely to be rooted in the subject matter or the context in which TA is used: Attributing the "lack of impact" of TA to the TA *concept* is at least one-sided.
Too little *empirically* based criticism is presented: I know of hardly any criticism that takes the trouble to evaluate TA studies in order to substantiate its statements. What is also striking are the sometimes adventurous "development phases" that TA is supposed to have gone through. In contrast, Naschold's description of the development of TA reads nicely – but remains empirically unsubstantiated. Naschold believes he can identify four "methodological stages of development": from a "social science extended cost-benefit or risk analysis" at the beginning to a comprehensive "identification and analysis of the entire range of [...] effects of technological development." Subsequently, "highly selective analyses for the identification of risk constellations" came to the fore, whereas today this approach is being broadened "in the sense of an intensive 'comprehensiveness'" (Naschold 1987, p. 14f.).
Requirements are formulated that are incompatible with the TA approach: Where this is aimed at policy advice, for example, it is in some ways pointless to constantly criticize the resulting analytical limitations.
Almost every critical topos of the 1980s was already formulated and discussed in the 1970s: But as a rule, no reference is made to them.

is sent into the race as a trendsetter. Complementary as well as alternative research efforts on the subject of "technology impacts" are being called for and in some cases also practiced: Model assessment (Dierkes 1988), technology genesis (Rammert 1988, 1990) and (socially acceptable) technology design (von Alemann/Schatz 1986) appear as new paradigms on the stage. Reversal and renunciation are demanded: The application orientation and practical relevance of TA are problematized, and in the light of "fruitful theoretical perspectives" (Dierkes 1988, p. 51) and a theory-led analytical curiosity, "research" rather than "assessment" efforts[2] (von Thienen 1989; Spinner 1989; Lutz 1990) now seem to be the order of the day.

Shouldn't all this be seen as positive? Has the "caravan of science" (Knie 1989) not rightly moved on, and have the research interests not formed differently and innovatively[3]? Such an assessment should by no means be contradicted at this point. But is it still possible to keep track of this new formation? And where has the "caravan" now reached in its movement away from first-generation TA toward "second-generation" TA (Memorandum Verbund Technikforschung 1984) – or is it still on its way? With so much movement and reorientation, what would be "contemporary" for technology research (Hack 1989, p. 71), and where would we find the functional place for technology assessment (modernized) in view of the "massive additional need for technology research" (Lutz 1990, p. 621)?

This is where the following considerations come in: First, we should briefly recall what Naschold calls the "classical paradigm" (Naschold 1987) of technology

2 The official language of the BMFT [German Federal Ministry of Research and Technology; the editors] now distinguishes between technology *assessment* and technology impact *research*. *Assessment* means (systematic) "efforts to enable the most rational possible evaluation of technical progress and the solutions to problems that can be achieved through technology." *Research* is defined as the "scientific, i.e., theoretically oriented and methodically controlled acquisition of necessary information" (BMFT 1989, p. 10) and is regarded as a prerequisite for consultation in discourse, i.e., assessment. Incidentally, the tenor of the official characterization of the SoTech program in North Rhine-Westphalia is very similar.

3 There is also a lot of activity elsewhere, where many new things are being tried out and old ones revived. Examples can be found in Joerges, who reports on the design of a "New Sociology of Technology" (NST) (Joerges 1989), or Eichberg, who retrospectively reports a "paradigm shift" from the guild of historians of technology (Eichberg 1987). Finally, Hack informs us about a "new type of technology studies" and its programmatic foundations, as it emerged at an international workshop of technology sociologists and historians in 1984 (Hack 1989, p. 72ff.).

assessment, as it was introduced and (mostly differently) practiced as an analytical and advisory concept at the end of the 1960s.

Criticism of and alternatives to TA will then be examined. This includes, in particular, social science technology (impact) research, from whose ranks fundamental criticism of TA can be heard. It is of particular interest insofar as it works both explicitly and implicitly with maxims and strategic research imperatives, which are claimed to be the basis for an analytically (and sometimes also politically) appropriate approach to the object of knowledge, technology (consequences).

Finally, we should discuss whether such "extra-paradigmatic" developments (Naschold 1987, p. 30ff.) could be made usable for the classical TA concept and its working practice.

1. The classic TA paradigm

The starting point would be the assertion that there is (or has been) such a thing as a "classic" paradigm of technology assessment. This requires a little reminiscing – remembering the concepts of technology assessment that first emerged in the United States in the mid-1960s. These were a reflex and part of increasing discussions about the significance and – in particular negative – consequences of the use of certain technologies. In this context, the question of the limits and possibilities of political control and shaping of technological development was also raised.

The qualitatively new aspect of technology assessment, which at the same time distinguished it from related impact analyses and research directions, lay in a sum of regulative points of orientation, which can be reconstructed from the conceptual ideas of the time about a new, application-oriented technology analysis in the following way (Paschen 1986; see also Gray 1982; Lohmeyer 1984, p. 56ff.; Paschen/Petermann 1992):

- Systematic identification of as many socially relevant effects as possible (comprehensiveness):
  The positive and negative effects of a technology or technology family should be analyzed in as many sectors as possible, such as the economy, politics, society, law, ecology, etc., as well as their interrelationships.
- Anticipatory orientation (early warning):
  Possible "futures" should be described and evaluated in order to be able

to react in good time ("timeliness") to undesired consequences or to bring about desired consequences.

- Focus of the analysis on the consequences that are not immediately recognizable:
  Where traditional impact and risk analyses tend to refer to consequences that have already occurred or are imminent in the short term, technology assessment should analyze and evaluate long-term secondary, indirect, and synergistic consequences in particular.
- Recording and evaluating social opportunities and risks:
  As far as possible, impacts should be analyzed and evaluated in a comprehensive sense, going beyond the merely quantifying, technically-oriented impact assessment to also include qualitative, social costs and risk potentials.
- Interdisciplinarity of the analysis:
  In line with the diversity and complexity of the impact areas, TA should be designed and carried out on an interdisciplinary basis.

This – more scientific – side of the program of technology assessment was enriched on the one hand with the demand for participatory design and on the other hand was constitutively coupled with the postulate of application or decision orientation. Therefore, the following continued to be essential for TA:

- Participation:
  Affected individuals and interest groups should be involved in the analysis and evaluation in order to improve the information base and document the different points of view and assessments.
- Identifying options for action:
  The aim was to formulate various options for action in terms of alternative possibilities. Options and alternatives should relate both to the technology and to the surrounding social structures. As a contribution to planning and decision-making, technology assessment was conceived as part of the decision-making process of individuals and institutions.

TA was thus – on the one hand – from the outset a utopian program of knowledge production with practical intentions. Accordingly, concrete TA activities – measured against the program – always had to be deficient in some respect.

On the other hand, however, TA as an interdisciplinary and multi-perspective analysis concept represented the approach of an integral technology analysis in terms of research strategy, which is nowadays demanded by consensus. It is true that TA was and is not based on the idea of integrating the determinants of technology into a "techno-*genetic* explanatory scheme" (Schneider 1989, p. 27;

emphasis added by the author). However, the description and explication of the status quo and future developments were and are always strategically guided in such a way that the various relevant factors of developments and the development possibilities of individual technologies can be addressed through interdisciplinary work.

If one reconstructs the classic TA paradigm at the conceptual and strategic level, it becomes clear that much of the criticism of its shortcomings that is voiced today in a tone of conviction is in fact preaching to the converted. This is because the *programmatic* interpretation of TA has always been such that the majority of critical elements have always been taken into account.

To name just one example: The assertion that TA is "reactive" and not interested in the timely design and control of technologies. Read Daddario, who emphasizes that the expected effects of technologies should be identified "in advance of their crystallization," the public informed and measures taken against problematic developments – "to eliminate or minimize" (cited in Lohmeyer 1984, p. 5). In view of these and other statements, what is supposed to be new about the concept of "constructive TA"? I don't know. It will also be interesting to see when and how the supposedly new paradigm of "constructive TA" materializes in studies, research results, and consulting practice.

Irrespective of the fact that the concept and strategy of classical TA certainly corresponded to a large number of the current demands for an interdisciplinary, design-oriented analysis of technology that takes social contexts into account, there is still the criticism of the inadequate implementation of the TA postulates and certain technocratic and scientistic stunting of the concept. And this indeed has sufficient empirical validity (OECD 1978, 1983; Shrader-Frechette 1982; Conrad 1986; Jochem 1988).

2. The classic criticism topoi of the 1960s and 1970s

Early on, the danger of the embarrassment of ambitious programs through practice became the focus of the TA debate. It was noted above all that the usual assessments of a technology were based on a false concept of technology: Technologies were seen as predetermined and unchangeable, their social constitution was at best implied by the trivial formula of the Janus-faced nature of use: "Technology may be used for good or evil." (Winner 1977, p. 357).

Wynne criticized the prevailing understanding of technology as a purely material artefact and expression of rationality and objectivity as a "technological

superfix" of TA with a specific consequence: The description and "evaluation" of technology and its consequences proceeded in a technocratic-rationalistic linguistic style, as if the emergence and use of technology could be negotiated exclusively and appropriately "objectively-scientifically,"[4] i.e., without touching on the ideological, symbolic, and political implications of processes of technology development and use. However, as Wynne later explained following some findings from the sociology of knowledge, different social paradigms of the perception and description of reality always exist side by side. A single paradigm for describing, for example, a large-scale technology (and its risks) can therefore never fully capture reality and only feigns "objectivity" (Wynne 1983a).

For these and other reasons, an alternative approach to research was called for: Away from the assessment and evaluation of a technology as such toward an analysis of society – "the proper point of departure is not to assess technology but to assess society"; away from the misunderstood impact analysis toward the generation mechanisms of technological innovations – the analysis of the

> [...] mechanisms through which social, economic, and political forces manifest themselves to give rise to new technologies. Public policy, therefore, should not be aimed so much at controlling specific new devices, as it should be directed more at identifying, analyzing, and perfecting the inducement mechanism (Holt 1977, p. 285).

Finally, a critical reflection on the fundamental problems of scientific and technological civilization was called for, "technology criticism" instead of an affirmatively charged "technology assessment" (Winner 1977, p. 350).

Critical social analysis and reflection on the conditions under which technology is created and implemented, however, require interdisciplinary technology research that goes beyond technology-focused approaches, according to another criticism. In this sense, Hoos criticized the methodological narrowness of so-called TA studies and the technicist orientation of the institutions conducting them. The technocratic bias, as expressed in the unreflected adoption of systems

4 "By reference to the objectivity of scientific knowledge and to the purely material character of technology, the proponents of the econometric systems language, and its 'social indicators' twin can assert that the employment of this paradigm as the only mode of cognition is an objective act in itself. When we understand that the very act of entry into such a mode of discourse involves the acceptance of a particular frame of reference, and of a wide range of culturally conditioned associations, meanings, etc. of which one may not even be aware, and which are beyond one's own control and personal definition of the situation, then we are in the position to reject their colonization of social reality" (Wynne 1975, p. 136).

analysis and cost-benefits analysis, results in rigid economism and the neglect of social values and interests (Hoos 1977). "While paying lipservice to 'social aspects'" – Skolimowski diagnosed – "the overall tenor, methodology, and conclusions are technical: a technical exercise performed by technicians" (Skolimowski 1976, p. 422).

Finally, as the fourth dimension of the TA criticism syndrome, the demand was emphasized that TA should not remain confined to the given technologies and the political decisions behind them, but should aim at a technology introduction and design that is socially acceptable to all groups. Furthermore, alternative technologies, strategies of non-introduction, and the social, non-technical possibilities for action and design should be included in the analysis – and this using participatory approaches (Lohmeyer 1984, p. 171ff.).

This aspect indicates that criticism of the *analytical approach* and *understanding of technology* could not be separated from the question of the use and objectives of anticipatory technology research. A look at the criticism of the 1960s and 1970s shows the paradoxical situation (which is still widespread today) that, on the one hand, TA was seen as a counterproductive thoughtfulness that could hinder the rapid implementation of technical innovations – whether through political regulation based on TA or through TA-induced technological skepticism among the population – and, on the other hand, was attacked as a particularly perfidious variant of technocratic, capitalist elites for the implementation of technology.

Technology *assessment* thus shared essential deficits that were also diagnosed in the old paradigm of technology *research* – Hack calls it the "clearly predominant sociological form of thematizing 'technology' until well into the 1970s."

In Hack's depiction – from the "enlightened" perspective of the 1980s – the "basic pattern of sociological technological determinism" of the 1960s and 1970s is characterized by three aspects:

- The development of technology and the underlying scientific and technological knowledge were understood as processes exogenous to society, i.e., as something that took place and had to take place "outside of society," as it were, and according to its own laws. Sociology, like other social sciences, ultimately had to deal with the social consequences – such as changing qualification requirements, job losses, productivity increases, etc. – and, if necessary, with the conditions that could inhibit or promote this autonomous process of scientific and technological development. The development of science and technology was seen as a "black box" that social scientists (and politicians) should keep their hands off.

- "Technology" was primarily understood to mean individual technical artifacts, tangible items such as machine tools, motor vehicles, telephones, or phototypesetting machines. The social significance of such a technical "object" lay in the object itself and therefore had nothing to do with the process of its production.
- This in turn meant that technologies were seen purely statically, "ontologically" so to speak: they were "there" and their mere existence implied social opportunities, problems, and dangers (Hack 1989, p. 728).

The 1960s and 1970s were already familiar with the main features of all those disputational topoi that are celebrating their heyday today: The analytical limitations and technocratic orientation of TA, the suppression of criticism and alternatives with regard to the object of knowledge "technology," and the TA analysts' lack of value sensitivity and willingness to shape. In addition to the continuity of this criticism, the 1980s also saw a qualitative intensification and supplementation by social science technology research, which will be of particular interest in the following.

3. TA as a deficient entity – especially from the perspective of social science technology research

Possible points of criticism, which prove to be consistent despite certain modifications, are the supposed presumptions inherent in the concept of TA. For example:

- TA means cognitive arrogance:
  Correct forecasts are neither possible, nor is it justifiable to derive consequences for policy action from forecast attempts that are doomed to failure (Radaj 1988).
- TA as science with practical (political) intent means crossing the border into the realm of politics. This is technocratic manipulation of freely elected politicians. Science should withdraw to the scientific (Pinkau 1987). Or: In order to avoid confusion between being and ought, a clean separation should be sought: Technology assessment research procures information (by scientific means) which is to be evaluated rationally (in a non-scientific way?) (BMFT 1989).
- TA implies "technology arrestment" and freedom-threatening subversion of the social market economy (Meier 1987).

- TA means a lubricant for the increasing mechanization of society and affirmative adaptation to the technological imperative of capitalism (Büllingen 1984) and its elites (Reese 1986).

Other critics provide important modifications of well-known TA criticism – despite an unmistakable continuity. Their concern is to expose the analytical deficits of "impact" assessment. Relative novelty can be attributed to the messages of those participants in the debate who have set their sights on impact research without consequences and its alleged passivity with regard to the design of technology.

- TA takes the second step before the first. What it lacks is a theory of technical change, understood as essentially social change and as a theory of the use of technology (Ropohl 1985, 1989; see also Lutz 1987).
- TA as "impact research" is in need of supplementation. It needs to be expanded "to include the process of generating and implementing technical innovations, which has been far less well researched to date" (Memorandum Verbund Technikforschung 1984).
- TA comes too late. What is needed is timely observation of the beginnings of technical innovations, especially the generation of knowledge (Ropohl 1985; Steinmüller 1987; Spinner 1989), possibly by the technology developers themselves (Langenheder 1986).
- TA is insensitive to values and norms. What is needed today is the value-conscious construction of futures and the discussion of the "why" of technology and its compatibility[5] (Zimmerli 1982; Roßnagel 1984).
- Because it is latently "deterministic," TA dethematizes the ways in which technology is used and how society deals with it. TA is therefore not seriously interested in a "design perspective" and based on "consequential determinism" (Ropohl 1985).
- TA is too scientistic and elitist. What is needed is a stakeholder orientation and decentralization as well as a strengthening of its discourse function.

5 "It is therefore a matter of us agreeing on what we want in such a way that we obtain a common picture of the desirable future, initially only a medium-term future. At this point, it becomes clear that both TA efforts and the efforts that have been increasingly observed in recent years and summarized under the term 'professional ethics' are turning into politics, i.e., into actions to generate consent or to reduce the refusal of acceptance. TA studies have to provide *casuistic* evidence in the form of 'if-then' scenarios segregated according to probabilities, while a politically approvable hierarchically structured value system of medium temporal range as 'residual ethics' co-determines which scenario will become the reality of the future on the basis of various professional ethics." (Zimmerli 1982, p. 154).

TA should not be conceived as an "expert model," but as a "social process" (Naschold 1987; Fricke 1989).

With this in mind, let us now take a look at some examples of alternative approaches to a renovated TA concept: Pinkau's "mission of technology assessment," Ropohl's "innovative technology assessment" and NOTA's [Netherlands Office of Technology Assessment; today Rathenau Instituut] "constructive TA."

- Pinkau's complaint is that the magical boundary between scientifically proven knowledge and political evaluation and decision[6] has been crossed, which he sees as a corruption of science (with detrimental consequences). Pinkau uses an absolute criterion of truth or a strict concept of law as the selection criterion for TA objects of investigation. All objects of knowledge that do not satisfy this methodological purism are eliminated, so that the only remaining objects of knowledge are those that permit statements of a legal nature, i.e., "extrapolations of the effects of natural sciences and engineering." This ensures the supposed neutrality (or reputation?) of science and, above all, solves the problem of action orientation through non-treatment.
- Ropohl criticizes the sleepiness of "reactive technology assessment": it waits "until certain technical developments have already taken on a certain form" instead of tackling "the sources of that stream" (Ropohl 1985, p. 236). Furthermore, since there is a lack of "basic scientific research" that provides "reliable" assumptions about effects, as well as a lack of "theories" that describe and explain "lawful relationships between technical objects and their non-technical fields of action" (Ropohl 1985, p. 234), TA is doomed to failure as an attempt to evaluate technology (too late, without orientation, taking the

6 Breaking down a TA process into two phases is a very plausible idea, but it suggests a *separation* and a *sequence* of scientific and non-scientific discourse that does not exist in reality. Firstly, in the "phase" of (in the language of the BMFT memorandum) technology assessment research, there are certainly not only elements of "science as such" (unless one subscribes to the fiction of pure scientificity), and that the "evaluation" phase should be unscientific – this idea is probably due to the opinion that one can make scientific statements about wheat prices, energy equivalents, and emission values, but not about interests, values, and motives. Secondly, technology impact research does not start from scratch, but is already influenced by assessment processes relating to a technology that take place before the so-called scientific analysis. And this is itself (at least implicitly) an act of evaluation or part of overall social evaluation processes.
Perhaps it would make sense to understand research and evaluation aspects, whose existence is not to be denied, as different *functions* of a TA process, and not to start from the idea of a pure separation and sequence of two different activities.

second step before the first).

Ropohl believes that by intensifying (exemplary) research efforts (on case studies of technical change) on the one hand and theoretical work on the other, i.e., by formulating a theory of technical change that enables statements to be made about cause-and-effect relationships, the information and forecasting problem of prospective technology analysis can be better overcome. This then becomes a prerequisite for not only "reacting" to developments (as TA does), but also for being able to intervene in a normative and formative way at the beginnings of technological development.

- The NOTA approach addresses the unsatisfactory results of TA from the perspective of the "control dilemma" (Collingridge 1980), on the one hand, and from the perspective of mediation or the addressee, on the other hand. Similar to Ropohl, a timely *and* active (= constructive) influence on technology design is postulated (i.e., considered possible) and programmatically supplemented by the claim to organize this design mandate in democratic and transparent processes with those affected. Following Naschold, Fricke ascribes the following characteristics to "constructive technology assessment" or "technology assessment as a social process": process orientation, use of empirical knowledge, participation concepts, and a combination of decentralization and forward-looking regulation of technology design (Fricke 1989, p. 23ff.).

However, a review of the nagging discourse on TA would be incomplete without a more precise insight into the debates in social science technology research. The motifs of interest for our context revolve around the central critical topos of technological determinism, which, originally directed at other approaches and research directions, is also blamed on TA.

In most cases, this means that TA is (politically or in the process of gaining knowledge) fixated on a given technology, ignores social causes and framework conditions, and ultimately discusses consequences with the appearance of inevitability and a lack of influenceability. This criticism, which often also presents itself as a debate about an appropriate concept of technology, conveys different things: Firstly, the assumption of technological determinism is varied as a lack of critical reflection and discussion of available technologies, secondly as a danger of reducing the analysis, and thirdly as an assumption of a lack of interest in practical design options. From Ropohl's point of view, the first two aspects could be classified as "genetic" determinism, the third as "consequential" determinism (Ropohl 1989).

- A large number of TA studies, it is claimed rather than proven, create the impression of uncritical acceptance due to their concentration on a given technology and its possible consequences and, by failing to problematize *this* technology and, above all, by ignoring *alternatives* in the form of *other* technologies, suggest that this technology is simply there, that one has to make use of it and adapt to its (inevitable) consequences. "The 'technology factor' thus remains to certain extent 'outside,' is de facto treated as an 'exogenous variable'" (Joerges 1989, p. 58). Even "social strategies" as non-technical solution options would be ignored by such a form of fixation on technology. A sub-case of this accentuation of criticism could be seen as the demand to make the social "desirability" of a technology the topic instead of its "actuality" – TA as the construction of desirable futures, the answer to the question of "what for"? For a long time, this and the fact that TA was closely linked to the political system led to the dominance of profitability analyses and feasibility studies, based on given technologies that seemed to have no alternative.
- The accusation that TA is subject to analytical (and, where it is popular, political) reductionism is also articulated and varied, insofar as it allegedly or actually does not sufficiently address the social and political environment in which a technology is embedded. This criticism points out that technologies cannot be reduced to artifacts, but must be understood as "networks" or complex socio-technical systems. For this reason, the social and political, but also technical "boundary conditions" of a technology in their interplay with its "form" and functional fulfillment (or failure) are a *constitutive* part of a technology assessment. However, it is not possible to capture this adequately if one concentrates too much on the "real technology" or the artifact – as is usually the case with TA – and hardly accounts for the social environment and its actors.

  Since TA is also not dedicated to the "social networking of scientific technological production processes" (Hack 1989, p. 77), since it does not follow the early tracks (Knorr-Cetina 1984; Hack/Hack 1985) of a technology (which begin in the laboratories of basic research), since it does not take into account the interests and values, the knowledge structures and world views that "materialize" there in technologies, it never reaches an adequate understanding of its subject and is therefore also not in a position to make accurate statements about "consequences."
- The third form of the accusation of technology determinism and the "consequence fixation" of TA focuses on the possibility or willingness to contribute

to the "design" of a technology by means of an impact assessment. On the one hand, this variant of criticism also has something to do with a (real or assumed) deficient concept of technology: If technology (development) is understood as an autonomous process (or exogenous factor) and not as a social process, then the "shaping" perspective is a priori omitted, or it is reduced to adaptation. Secondly, the criticism is also articulated as a reference to the unresolved "control dilemma" (Johnston 1984) of TA: It always comes too late to be able to really decisively change (shape) techniques that are already "entrenched." Finally, a variant of the criticism of design blindness could be the insinuation that TA targets the wrong addressees, namely so-called decision-makers at a distance, the "application elites," but not those "affected" on the ground.

4. If there were something to be learned – what would there be to learn?

If we now apply these requirements to TA, it would have to reorient itself in the following respects:

(a) Its concept of technology should abandon a "naïve *technological* determinism" (Winner 1980), without being taken in by a voluntaristic idea of the *social* determinism of technology.
It must be admitted that for a long time, the practice of TA was dominated by a mostly implicit, but nonetheless effective, understanding of technology as an artefact that could at best be understood phenomenologically: Either technologies were regarded as the *results* of diffuse innovation processes, which in turn were declared as not worthy of further analysis. Or: they were understood as an unquestioned, predetermined component of social reality, which, so to speak, causes consequences of *its own accord* (autodynamically), to which individuals or systems have to adapt through political, economic, and social structural reorientation *due to practical constraints*.

A reorientation of TA practice – which can already be seen to some extent – will have to be based on a fundamental insight. Regardless of whether technology is understood as an unexplained *resultant* in terms of its generation patterns or as a largely unquestioned *cause* of certain consequences in terms of its form determination and modes of action: The reciprocal entanglement of technical

and social processes can only be insufficiently addressed in a technology-centered stimulus-response scheme, let alone meaningfully analyzed and evaluated.[7]

Technology in the trade-off between the control intentions and control performances of cooperating and competing actors, technology as the result of their negotiation processes, the social form of technology, influenced by social subsystems such as science, law, the market, and politics, technology as a social process (Fleischmann/Esser 1989; Hack 1984; Weingart 1989) – these aspects should become self-evident orientations for common forms of technology assessment.

(b) The social interdependence of technologies means that any attempt to realize an "objective value-free analysis of the consequences of technological applications for society" (Wynne 1983a, p. 117) and a mode of TA as "non-partisan" (Gibbons/Gwinn 1986) is not feasible and must miss the social implications and symbolic dimensions of technologies and their character as a "social figuration" (von Borries 1980). The insight that "technology is a central element in the symbolic networks of society, legitimating certain forms of social conduct and organization by molding our consciousness via that implicit, condensed information which it transmits to us" was obscured not least by misunderstood postulates of value neutrality and a one-eyed addiction to quantification (Schrader-Frechette 1982). Technology itself now embodies certain institutional values, interests, and purposes" (Wynne 1975, p. 136).

It is the persistent positivist hesitancy of TA (Carley 1986) that has almost always marginalized the "value" of socio-technical systems as a question to this day.

In addition, the prevailing rationality of TA goes hand-in-hand with the adaptation to the actions and interests of (traditional) decision-makers as addressees. Interest in technology as a "function," for example, prevents interest in technology as a "symbol" (Hörning 1985) from arising in the first place. As a result of its finalization by politics, other concepts (problem-oriented TA), other time perspectives (long-term, retrospective), other dimensions of use – discourse

7 In particular, the cognitive dimensions of *technology development* and its organizational orientation and institutional framework conditions are neglected, and the actor-specific strategies of selection, interpretation, and design of technologies in the *context of development and introduction,* the "institutional focusing" (Dosi) of a technological paradigm, are inadequately taken into account. Finally, the "appropriation" dimension in the *implementation and utilization phase of technologies*, i.e., the integration or non-integration of human and technical actions and their interpretation in society, is at best a marginal issue (Joerges et al. 1985).

instead of decision, conceptual instead of instrumental use, consulting instead of decision support – and other thematic orientations – TA as "cultural analysis" (White 1986) – has hardly any market.

(c) A narrow concept of technology and the scientistic and elitist orientation of TA have also frequently obstructed the possibility of understanding technologies as being capable of being staged and shaped in line with specific social objectives (and of conceiving technology assessment accordingly as a component of processes of overall social technology assessment). In this sense, Arie Rip has pointed to the socio-cognitive dimensions of technological developments (Rip 1986) and at the same time to the lack of interest of traditional scientific analysis in the modes of discursive appropriation of technologies and technological consequences.

Whether such appropriation takes place as company negotiation processes or large-scale social disputes – these and other stylistic devices of staging are likely to have a significant influence on the "social form" of a technology and the so-called "consequences." From this perspective, it would be desirable for TA to be deliberately fed into social discussion contexts, i.e., to intervene in discourses (not only of elites) or even generate them. If TA were really to be understood and practiced as a "social assessment of technology" – as has long been demanded[8] – there would be no way around addressing and filling out this dimension in particular.

A number of conclusions for TA can be drawn from the maxim of analyzing technology as a social, value-based, and (potentially) shapeable process. They are, of course, of a general nature, one could also say "programmatic," so that for each specific TA process it would always have to be asked anew whether and to what extent the substantive and methodological concretization and practical research implementation could succeed.

- In order to avoid analytical "shortcomings" (Winner 1980), which can be detected time and again in concepts of technology assessment (Joerges et al. 1985), a view of technology should be adopted that conceives of social dimen-

8 However, it is then clear at least that the self-image of an institution practicing such a TA would have to be significantly different from what has (generally) been the case to date. It would have to understand its science as an interpretive and advocating research activity (and not leave the interpretation to politics/society).

sions of action in close connection with the factual character of technical artifacts[9].

- Technology assessment should be more interested in the reciprocal links between scientific and technical developments, as indicated by the trends toward the scientification of technology and the mechanization of science. Modern technologies are always also coagulated knowledge that essentially determines their logic. Such techniques can only be described from a narrow perspective if one does not take into account the institutional and cultural conditions of the production of scientific knowledge – including the engineering "construction styles" (Knie 1989) and "design hierarchies" (Clark 1985) that become effective here. Appropriate approaches for a "science assessment" would therefore have to be developed and tested (Deutscher Bundestag 1986). The same applies to the utilization of technology genesis research and a (yet to be developed) "sociology of invention" (Gilfillan).
- Technology assessment should, more than in the past, address the forms, strategies, and media of control of scientific and technological developments, both within and beyond the company, that are applied in cooperation and opposition by corporate (Nutt 1984; Thurley/Wood 1983), political-administrative, military (Tirman 1984), industrial, and scientific actors. If it does not sufficiently grasp these social processes of control or the determinants of the evolution of technologies, its conceptual deficits contribute to creating the appearance of a self-running technology. Therefore, "social risks" should be identified more consciously than in the past, insofar as they are induced by new technical principles and processes, more emphasis should be placed on analyzing the "decision-making calculations and constellations of interests that are decisive here," and it should be clarified "which problem situations, tensions and conflicts, unmet needs, or inadequately processed distortions exist" (Lutz 1986, p. 568f.).

9 In such an understanding, artifacts have the "character of action" (Braun 1986, p. 19). As an "intermediate element of human action," they constitute "technical social relations," in particular "through the institutional interlinking of the human parts of action with technology-integrated contexts of action" (Braun 1986, p. 23f.). However, technology also determines the social forms of action in relation to nature: "Technical relations contain an increasingly important section of social relations to nature" (Braun 1986, p. 25). The binding of human action to artefacts and the "socialization of nature" not only through its subjugation, but also through its "construction" are thus to be appreciated equally analytically (Joerges 1984).

From an action-theoretical perspective, however, a *voluntaristic* understanding of control and an overestimation of the creative openness of technologies must be avoided, as their "relative autonomy" (Dosi 1982) or "momentum" (Hughes 1969) should not be underestimated, nor should the stubbornness of social actors. Moreover, it is essential – especially if one wants to sound out the potential for design and action – to concentrate on the scientific-technical characteristics of a socio-technical system, i.e., the description and prospective analysis of the "real technology" (Ropohl), the appreciation of its respective "materiality" (Mambrey et al. 1986).

- TA should also consider the modes of cultural "staging" of technology (e.g., Rammert 1986, p. 33). New classifications of technical and human action systems, changed risk assumptions and perceptions, and the effects of the substitution services of technical systems must be culturally appropriated. Processes of such "transculturation" take different forms: The stubbornness of social actors can resist the intended use of technologies and technical innovations can also "generate" adjustments in attitudes and behavior – both with more- or less high social costs.
- Of particular importance from the perspective of cultural appropriation are the discourses and public debates that accompany technical innovations, the institutional-cultural embedding of actors who drive or slow down the process of technical developments, the media by means of which technical developments and development possibilities are negotiated, such as political discourse, morality, and law. Finally, these include "metaphors" (Zashin/Chapman 1974), "images of technology" (Huber 1989), "guiding principles" (Dierkes 1987), and myths, which are *also* an "expression" of the appropriation of technology, but are always more than this. This is precisely why they should be made the subject of technology assessment processes. Research in the social sciences and the history of technology has shown in many case studies that such discourses and images, as *social interpretations* of chosen paths of technologization, as elements of social appropriation of technologies, as representations of one's own and other people's interests, contribute significantly to social change in the context of technological advances. The assessment of their functions could therefore provide insights into the defense against or appropriation of technologies and the resulting repercussions on their form and perspectives of use.

In the face of such desiderata, debate is necessary, but composure is also called for. This is not so much because the shortcomings mentioned in the analysis

of techniques are by no means limited to TA, but also need to be remedied in other areas (Ropohl 1989, p. 1; Lutz 1990). Rather, *direct* research-pragmatic consequences for TA can only be drawn to a limited extent from the considerations outlined and the maxims formulated. The requirements discussed are more likely to be met directly by the *sociology of science,* which is better suited in terms of time perspective, content specialization, and specific epistemological interest, or critical technology-related *social research,* which – as a "descriptive concept" (Hack 1989, p. 81) – deals *ex-post* or *concomitantly* with the reconstruction and analysis of technological advances in the context of socio-structural change processes.

Lutz has described the previous "path to a new paradigm of technology research" as one that proceeded in two stages: The overcoming of technological determinism and the development of an understanding of technological development as a social process. At the same time, however, he points out that the development to date has taken place "without [...] the consequences of this having really been systematically drawn in research practice and scientific discussion" (Lutz 1990, p. 617).

As far as the practice of TA is concerned, a similar argument will have to be made: The "new questions" about the causes of the emergence of technologies that are used and appropriated by the actors, about the control of certain technologies and the neglect of others, and about the forces, interests, and arguments that play a role in this – *technology research* is struggling to answer these questions (Lutz 1990, ibid.), and *technology assessment* has at best made timid attempts to address them and is probably still a long way from finding answers.

The analytical dilemma is obvious: The characteristics of technical development

> [...] – industrial organization; gradualness; market mediation; surplus application potential; control by socio-economic interests and problems – can still be captured and described relatively easily retrospectively on the basis of earlier, long-past technical developments. This is much more difficult in the case of developments that are still in flux and the corresponding technological lines (Lutz 1990, p. 619).

And this dilemma continues in the attempt to "assess possible future courses and ramifications of technical lines of development" (Lutz 1990, p. 619).

The interest in explicative elements of a technology analysis is also difficult enough to implement in technology research – for TA as a prospective analysis, at best plausible argumentation steps remain here in order to be able to assert possible correlations or constellations of social and technical parameters in evolutionary developments. If technology research intends to "reconstructively catch

up with the mechanisms and tendencies operating blindly" (Hack 1989, p. 96) in addition to analyzing intended, planned research activities, it is obvious what difficulties a *prospective* analysis would have with this. After all, it lacks precisely the historical material that is available, for example, previous attempts at technology genesis research.

For a technology assessment of *future* developments or development possibilities that is concerned with utilization and usefulness, the new perspectives of technology research mentioned above can hardly be directly translated into application-oriented research strategies and project designs, let alone conceived in the foreseeable future as advisory discourses for decision-makers working with other rationalities. There are evident methodological and epistemological barriers to this – not to mention the conditioning of individuals and institutions by their clients and sponsors.

However, certain barriers may need to be overcome. This presupposes that general requirements for an appropriate analytical approach to technology, such as the thematization of actor aspects (Rammert 1986), the consideration of "contexts of use, production, and disposal," "eco-contexts" (Joerges 1989), "cultural milieus" (Nedelmann 1986), etc. are operationalized for tangible TA topics. There may be good reason to call for a shift in research interest away from the analysis of consequences and toward issues of production and use (Memorandum Verbund Technikforschung 1984) – good reasons for intensifying TA research using findings and methods from research on genesis and use must be asserted in more than just the abstract. If the claimed *complementarity* of generation- and impact analyses is taken seriously, it would have to be examined whether there could be a pathway between social science technology research and TA that enables meaningful transfers that stimulate the TA practice of anticipatory analyses. The same applies to the question of common intersections between historical-empirical technology research and theory-based technology research.

I would like to cite three examples of communication transfers:

- The question of a connection between TA and a theory of technical change is still awaiting at least an attempt at an answer.
  In this context, Ropohl speaks of the "lack of theoretical, interdisciplinary technology research" and asks: "How can technology impact analysis be carried out in practice if there is a lack of scientifically tested hypotheses about eco-technical and socio-technical interdependencies? How can the results of a technology assessment be fed into the mechanization process if the 'mechanisms' of technological development have by no means been

theoretically clarified? Technology assessment studies thus prove to be ad hoc undertakings that attempt to take the second step before the first, so to speak. In any case, a technology assessment that not only reactively considers the consequences of an innovation that has already been implemented, but also wants to intervene innovatively in the design of new technologies, excludes any technological determinism; this naturally also applies to technology research that is intended to create a theoretical basis for such technology assessment" (Ropohl 1989, p. 1).

In my opinion, we do not need a "theory" of technical change in order to conduct TA, but we do need systematic orientation.[10] These can be gained from theoretical work on the explanation of innovations, from theoretical and empirical work on the actors and determining structures involved (Ridder 1986), and from predominantly empirical studies on the development forms and phases of individual technologies.

Conversely, the "bundling" of TA results could also make a contribution to the "systematics" of socio-technical development processes if such singular results were integrated "into generalized bodies of knowledge about the relationships between technical development and social, ecological, economic, and political systems" (Dierkes 1991, p. 24).

- The Bremen Expert Commission "Arbeit und Technik" [Work and Technology, the editors] concretizes its concern for historical-social science technology research in the form of two steps (Sachverständigen-Kommission 1988, p. 90ff.):
  - the empirical-statistical long-term analysis of the objective developmental moments of the emergence, introduction, and spread of new technologies and
  - the historical-genetic interpretation of design theory and the development of engineering methods as well as the analysis of specific problem-solving patterns and strategies for individual techniques.

10 We may, for example, learn from the abundance of technology-push and demand-pull studies on the dissemination of technological innovations (Mowery/Rosenberg 1979) that – even in retrospect – the course of these processes is almost "Tolstoyan," i.e., its determinants can be roughly described but ultimately cannot be (rationally) explained. We *do have* material that could be used to develop a theory of technical change. But the material shows us (so far?) that the goal of finding and combining generalizable, time- and space-independent statements/explanations is hardly achievable.

As has become clear in similar programs, but also in individual projects in social science technology research, the objective of such analytical approaches could certainly be achievable:

— Data on volume and structural develop-ment from specific sectors of the manufacturing industry or the products and processes to be examined could provide assistance in classifying the preferred problem-solving strategies in each case.
— Long-term observations could relativize the "laws of development" of energy and information technologies that are often regarded as valid – which often obstruct alternative perspectives.
— Quantitative analyses of individual – completed – technology developments could, in particular, work out the characteristics of design goals, principles, and problem-solving patterns, identify abandoned technology developments, and neglected design scope.

A TA that learns from history could benefit from such comparative approaches in technology and engineering research. But again the central problem of the transferability of findings gained from retrospective research to assessment processes that aim to anticipate lines of development arises here.
Nevertheless, the benefits of long-term technical assessments of selected branches of technology or comparative re-evaluations of technology-specific development patterns should not be underestimated for anticipatory analysis and evaluation. In the discussion about the assessment and evaluation of the potential consequences of individual technologies and in the search for perspectives for problem-appropriate technology design, the "design-oriented historical-comparative analysis" could provide argumentative support to "break up the appearance of a natural, logically determined technology genesis and development" and "expand the technical-scientific problem-solving horizon of future technology designers."

- Dierkes and Marz have concretized their considerations on "Leitbildforschung" (Dierkes/Marz 1990) to the extent that they have made proposals for the utilization of this approach for technology assessments (and thus for the control of technology). Their programmatic demands focus on three aspects:

  — Since TA has difficulties in determining the point in time at which the action strategies it formulates have to be applied in view of a certain stage of technological development, it could draw on insights from technology genesis research: "It could determine this critical point in perspective, if

not absolutely exactly, then more precisely" (Dierkes/Marz 1990, p. 39). The results regarding the diverse factors that control technology genesis ("factor network") could also be expected to contribute to the formulation of refined "control strategies" that are no longer "one-dimensional and microstructurally" oriented (Dierkes/Marz 1990, p. 40).

- Research on risk perception and the interaction of organizations, social movements, media etc. in the development of acceptance and acceptability of technologies could "reveal new control potentials outside of classical strategies" (Dierkes/Marz 1990, ibid.).
- Terms and concepts of the techno-genetic research approach such as "construction and research tradition" (or "style"), "organizational and corporate culture," and, last but not least, the "mission statement" could stimulate reflections on complementary or alternative models of technology management.

It seems to me that there are interesting parallels between ex-post oriented genetic research and anticipatory assessments of pre-competitive technologies, in that early technology assessment is to a certain extent following in the footsteps of an emerging technology, so to speak. If, for example, the AFAS[11] – as in some projects in the field of information and communication technologies and artificial intelligence – uses the methods of personal experience with the technology or the means of prototype development (as a method of technology research) to seek information about possible future consequences, then something like an analysis of the factors of technology genesis is also carried out here – only prospectively. These parallels and similarities would be an interesting point of contact for joint communication between technology researchers and TA analysts – irrespective of differences such as methods and interest in knowledge

5. Concluding remarks

There is no need to warn against high expectations regarding communication between technology research and technology assessment – they are unlikely to arise. I see a possible modest yield for TA – assuming a mutual acknowledgement – on the level of intellectual stimulation and a strengthening of the awareness that for TA technologies are to be described more as social processes than before.

11 *Editors' note*: AFAS – Abteilung für Angewandte Systemanalyse (Department of Applied Systems Analysis) of the former Research Center Karlsruhe.

The – indirect – benefits to be gained from social science approaches to technology research, the sense of thematizing and reflecting on the concept of technology, the yield of technology-historical studies (Kranakis 1987) could lie for TA on the one hand in a (self-)enlightenment function and on the other hand in the possibility of obtaining topics, questions, and (meta-)criteria for the assessment and evaluation of technologies or technology families or their alternatives, as well as associated possible social change or persistence tendencies.

TA as a "social assessment" of technologies could do with further development. Not least because of this, it would perhaps also be possible to awaken an understanding of the fact that social consequences can neither be directly derived from the technical-physical characteristics of a technology nor from economic data, nor can the social desirability of a specific use of technology be justified.

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