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Introducing early conceptual development of TA in Germany

> Thus, the history of TA itself can be interpreted as a tentative experimentation and constant learning process, in which each new approach claims to avoid certain shortcomings of the known approaches, but in doing so raises new questions and produces other shortcomings (Grunwald 1998, p. 2).

Technology assessment (TA) can look back on a history of over 50 years. It owes its current form (cf. Böschen et al. 2021; Grunwald 2024) to a multitude of practical experiences and theoretical debates, spread across different industrialized countries with different focal points and at different times. The 1980s and 1990s were a time of turbulent development, with social crises, new global political constellations, and changing perceptions of problems. Examples include the growing awareness of the global environmental consequences of human civilization such as the hole in the ozone layer and climate change, the nuclear arms race during the Cold War, the accident at the Chernobyl nuclear power plant in 1996, the collapse of the communist regimes in Eastern Europe, the neoliberal conversion of most economies in the wake of Margaret Thatcher and Ronald Reagan, but also the Brundtland Report on Sustainable Development (WCED 1987). TA at that time was characterized by theoretical controversies, new conceptual developments, and diverse practical experiences, often against the background of the diagnosis of a "risk society" (Beck 1986). Examples include social constructivist technology research (Bijker et al. 1987), the development of constructive TA (Rip et al. 1995), the founding of the European Parliamentary Technology Assessment (EPTA) network in 1990, the closure of the Office of Technology Assessment (OTA) in the U.S. Congress in 1995 (Bimber 1996), the debate on the relationship between TA and ethics (Grunwald 1999), and the participatory expansion of TA (Joss/Belucci 2002). Many of these topics focused on the role of the state, the possibility of scientific but non-technocratic policy advice, precautionary issues, and the role of broader participation in view of the existential risks that were much discussed at the time (as they are today!). A wide range of analyses and perspectives on these debates were developed in Germany

that can still be followed today, particularly with regard to the conceptual and theoretical development of TA.[1]

In many cases, these fundamental works are difficult to access. In line with the conventions of the time, they were usually written in German and were often published in anthologies that are rarely, if ever, available digitally. This volume in English translation aims to change this by making these contributions from the 1980s and 1990s, which are still fruitful for capacity and community building in times of global TA (Hennen et al. 2023), accessible both for the TA community and beyond. This is done in particular with a view to use in the rapidly growing field of university education in the context of TA and analogous approaches such as Responsible Research and Innovation (RRI) (von Schomberg/Hankins 2019).

In order to preserve the original character of the articles, we have deliberately refrained from using the gender-neutral language that is common today. Events and terms that not every reader may be able to understand straightaway have been explained by the editors in footnotes. To improve readability, all quotations that were originally in German have also been translated. In addition, the bibliography has been revised and updated. Some of the sources cited were still in preparation or in print at the time of the original publication and are now easier for readers to find thanks to the updated information.

The main interest of this volume lies in the fact that the level of theoretical reflection on various aspects of TA, as it was carried out in Germany decades ago, is to be made accessible for the present and preserved for the future. Looking back, it is always striking, especially in comparison with the current rather pragmatic view of TA, at what level of theory and with what social theory models TA was discussed. It was often about fundamental questions of TA, e.g., whether it could achieve anything at all as policy advice, or whether participation was an important element, whereas today, small-scale questions such as the suitability of certain formats for online participation or institutional optimizations of policy advice are often discussed. Our aim is not to play one off against the other, but to maintain a fruitful relationship between theory and practice, or practice-oriented reflections.

The debates in the 1980s and 1990s have shown that this is possible and promising. On a theoretical level, the theory of communicative reason (Habermas

1 During the period under review, the Institute for Technology Assessment and Systems Analysis (ITAS) at the Karlsruhe Institute of Technology (KIT) was founded in 1995 as the successor to the Department for Applied Systems Analysis (AFAS). It is a nice coincidence that the ITAS, where a whole series of the chapters reprinted here originated, is celebrating its 30th birthday in the year this book is published.

1981) was intensively debated vis-à-vis sociological systems theory (Luhmann 1984), the "risk society" (Beck 1986) was discussed even in the feature pages of daily newspapers, the deliberative and participatory renewal of democracy was proclaimed in terms of democratic theory (Habermas 1992; Barber 1986), there were far-reaching debates in the context of the emerging ethics of the future (Jonas 1979) and sustainable development (WCED 1987). In the discussions on TA, these major theoretical lines were taken seriously and integrated into the field.

The selection of texts for reprinting in this book was based on the main criterion of addressing conceptual and theoretical questions that are still relevant today and have left visible and relevant traces in the development of TA. In several rounds, the editors repeatedly looked through and compared countless texts from this perspective, which ultimately resulted in the spectrum realized in this volume. These texts were then translated – many thanks go to Sylke Wintzer, Miriam Miklitz, and Julie Cook, who prepared this volume in English in their usual excellent manner. Thanks also go to Gabi Petermann, who compiled and edited the literature.

In the following, the reprinted contributions are briefly presented individually according to the order they appear in the book. The editors have developed four categories to structure the collection:

- Risk as a key concept in TA – the problem-oriented dimension
- TA as advice – the consultative dimension
- TA as communication and participation – the discursive dimension
- TA as a theoretical approach – the action-theoretical and system-analytical dimension

Through this structure, we briefly describe the contents of the individual chapters with a focus on the respective theoretical and conceptual basic questions of TA, explain the authors' theses, place them in the context of the time of their creation, and ask about their relevance for TA today and in the future.

1. Overview of articles in the volume

1.1 Risk as a key concept in TA – the problem-oriented dimension

Technology assessment was established as a response to the rise of a great variety of technologies, highlighting the need for research and advice on its probable (negative) consequences. The focus of TA has always been on the trade-off be-

tween the good and the bad sides of technology impacts, and as such on risks induced by technologies. The Technology Assessment Act of 1972, which led to the establishment of the Office of Technology Assessment (OTA) in the United States, aimed "to provide early indications of the probable beneficial and adverse impacts of the applications of technology" (U.S. Congress 1972, Sec. 3c). And the establishment of the Office of Technology Assessment at the German Bundestag (TAB) was justified in the constituting decision in 1989 as follows: "The German Bundestag must help to exploit the opportunities offered by new technologies and to minimize the risks" (German Bundestag 1989). Thus, the concept of risk can be seen as the backbone of TA. Analyzing risk as probable negative consequences perfectly meets the task of TA to reflect on non-intended, negative impacts a technology might bring in the future. Therefore, it comes as no surprise that the term risk is widely addressed in early TA publications. The concepts of risk covered objective risk assessment methods, subjective risk perception research, and risk as a constituent paradigm of modern societies, synthesized in the famous "risk society" concept of Ulrich Beck (1986). It is striking to see that the concepts of risk in TA combines two research lines, where the passion for risk-oriented method pragmatism in the U.S. meets the German passion for social theorizing on risk. How is that reflected in early German TA publications?

Overview of articles:[2]

(1) Bechmann, Gotthard (1994): Early warning – the Achilles' heel of technology assessment (TA)? (*original title:* Frühwarnung – die Achillesferse der Technikfolgenabschätzung (TA)?)
(2) Renn, Ortwin (1982): Methods and procedures of technology assessment and technology evaluation (*original title*: Methoden und Verfahren der Technikfolgenabschätzung und der Technologiebewertung)
(3) Münch, Erwin & Renn, Ortwin (1981): Safety for technology and society – theory and perception of risk (*original title*: Sicherheit für Technik und Gesellschaft – Theorie und Wahrnehmung des Risikos)
(4) Bechmann, Gotthard (1993): Risk as a key category of social theory (*original title*: Risiko als Schlüsselkategorie der Gesellschaftstheorie)

The contribution by *Gotthard Bechmann* (1994) in Chapter 1 discusses the topic of early warning as a distinctive technology assessment function to address future assessment needs. The anticipatory, future-oriented focus is indeed a key characteristic of TA – back then in the early days as well as today. Early warning is

2 For full bibliographic details, see the list at the end of this chapter.

supposed to identify technology consequences as early as possible, prevent its negative impacts, and provide prospective knowledge on possible future action. Bechmann critically reflects on several dimensions of early warning, i.e., its time, objective, and social dimensions. Just like other forms of foresight, early warning shares a common dilemma: If the warning is successful, then no one can see whether what was warned against would have occurred at all. If the warning is not considered and the damage occurs, then the warning was useless. However, what is emphasized is TA's need for future assessment. The core business of TA is assessing future non-intended (and hence negative) technology consequences and impacts – and thus directly follows from the crucial term of risk, namely its future probability dimension and its emphasis on non-intended damage-oriented consequences. Foresight and prediction as key aspects of TA are then reflected from various perspectives. The role of time and temporalities of future considerations within a changing – or not changing – environment are discussed, resulting in a foresight dilemma: There are various forms of foresight to assess possible futures, and on the one hand foresight serves technology assessment as an informative decision-making tool, but on the other it stands on the shaky ground of uncertain probability statements.

Early warning is still an essential part of today's TA activities in the field of future studies, scenario development, and modeling and simulation. This includes prospective impact and ex-ante consequence analysis where the emphasis now is on developing detailed method integration techniques as in the field of scenarios and modeling, or analysis of expectations (e.g., vision assessment). In addition, early warning has benefited from progress and innovation within information and communication technologies. Here, real-time (big) data mining and analysis aim at early warning signals in technology and earth systems (e.g., cyber-attack, tsunami, volcano).

Chapter 2 by *Ortwin Renn*, originally published in 1982, discusses the methodological diversity of technology assessment and technology evaluation. The concept of risk is at the center of methodological considerations. Technological risk, understood as a probabilistic consequence of damage, is reflected in different methodological variants. The focus here is on the epistemic and methodological robustness of the risk statement in relation to important facets of technology assessment, for example, the identification of different harmful consequences, the relationship between benefit and risk, the uncertainty of statements about the future, or the role of objectivity and subjectivity in the assessment of consequences. The methods discussed are assigned to different categories such as technology-oriented methods (e.g., cost-benefit analysis, revealed/expressed

preferences), economically-oriented methods (e.g., welfare theories, marginal cost analysis), politically-oriented approaches (e.g., voting and participation procedures, muddling through), and systematic weighing procedures (e.g., benefit-risk analysis, multi-attributive decision, planning models). Finally, the scenario technique, the interdependency approach, and the basic need concept are dealt with under system-analytical approaches. The concept of risk is consistently reflected in its diverse methodological implementation and methodological theorization as well as in very different methodological specifications, covering formal-mathematical calculations, subjective gains of utility for majorities, legitimacy of collective policy decisions, or a combination of quantified consequences and value preferences. Many of the risk-considering methods which are discussed are prominent in empirical pragmatically-oriented research in the US.

Today, there are two ways in which TA methods work can be done. On the one hand, the different TA methods for assessment and evaluation have been systematically compiled and classified within several TA handbooks and manuals, providing easy orientation and guidelines for TA practices. On the other hand, method development with a focus on interdisciplinary and transdisciplinary integration efforts is widespread, for example, energy scenario development or living-lab and real-world lab research.

Chapter 3 on theory and risk perception by *Erwin Münch & Ortwin Renn* (1981) addresses security considerations of technologies within societies. It introduces risk as a multidimensional concept that can mean very different things to different people: Gamblers' expectations of winning, calculations of life expectancy, the future market success of businesses, or the prospects of success or failure of medical surgery. It is obvious that risk consideration and evaluation is used in very different situations, and with a very different understanding. The occurrence of probability calculations and assessments is the common feature of these situations. However, it is clear that probability estimations have their limits, both objectively and subjectively. Objectively, they rely on the law of large numbers of events, i.e., point predictions are not possible with only a small number of events, and subjectively, they rely on individual intuitive risk perception patterns. Thus, risk is foremost a social construct between objective and rational calculation and subjective and irrational (mis)interpretation. A key element is therefore the introduction of the psychology of intuitive risk perception, which paves the way for risk sociology. This is where the US-inspired empirical psychometric risk perception research of the 1970s enters the TA debate. Intuitive risk perception is based on perceived loss expectations, qualitative risk and benefit characteristics, and perceptions and opinions with regard to the sources of risk. Societal delibera-

tion processes on technology assessment need to take these mechanisms seriously for effective handling of risk technologies.

Subjective and individual risk perception research is still of great importance in TA. It forms the backbone of what has become technology acceptance and acceptability research within TA. The question of social resonance, risk perception, and levels of technology acceptance is one of the key research questions asked by stakeholders and decision-makers in any case of new and emerging technologies.

Chapter 4 on risk as a key category of social theory, also by *Gotthard Bechmann* (1993), combines the pragmatic method-oriented results of risk research with system-analytical social theory considerations in an excellent way. It reveals the different meanings and constructs of risk as a fundamental characteristic of what constitutes and shapes modern societies. In that sense, risk has become a functional-structural element of what defines the risk society. The concept of risk embodies the basic experiences and problems of a highly industrialized and highly scientific society as seen before the turn of the millennium. In short: Risk as a social theoretical concept. The very different roots and meanings of risk are well reflected here. Tracing the roots of risk back to the financial lending business in the Middle Ages reveals that interest reflects the risk of loss – and is no longer seen as usury. Risk is increasingly associated with different meanings and contextualizations: The universalization of risk awareness, the conceptual pairing of safety and risk, risk and decision-making, or risk in the sense of attribution are just some of the important nuances of risk discussed. Next, current social theory, focusing on systems theory and its functional differentiation of society, is reflected on the basis of risk concepts. Subsequently, both approaches are brought together, i.e., the structure of risk in modern times. The focus on technological risk reveals different forms, types, and temporal dimensions as well as their implications for and the responses of social systems and societies. And that is also where ethics, norms, and values come into play. Thus, it remains an open question whether risk and uncertainty constitute the starting point and backbone of what modern societies are experiencing.

It seems that the peak of social systems theorizing in Germany has come to an end since the turn of the millennium. Within the TA community, there currently seem to be no far-reaching ambitions to theorize on technology assessment and evaluation within the framework of long-term social systems theories. However, this reflects the fact that the passion for big theories is generally fading.

1.2 TA as advice – the consultative dimension

TA emerged as scientific policy advice in the U.S. Congress in response to demand from politicians (Bimber 1996). It builds on a long history of policy advice by scientists and experts, and in particular on the Think Tanks founded in the 1950s (e.g., RAND). The consultative dimension is deeply inscribed in TA through this history and subsequent developments: It works not only in a knowledge-based manner, but also as a knowledge-based transfer service of the scientific system to non-scientific addressees. The range of addressees has expanded considerably over time, even beyond policy advice (Grunwald 2024). The TA knowledge provided should enable informed opinion-forming and decision-making in various areas and find its way into social practices. TA should achieve "impact," as it is called today, through consultative activity (Decker/Ladikas 2004).

This expectation leads to a wealth of questions and challenges, which are primarily due to the TA constellation of consultants and consultees, in which TA as a consultant both wants to and should achieve an impact, but in which the opinion-forming and decision-making of the addressees, e.g., in parliaments, should not be technocratically predetermined or even determined. In the 1980s and 1990s, the foundations were laid for the high level of theoretical insight and practical experience that exists today.

Overview of articles:

(5) Mayntz, Renate (1986): Learning processes: Problems of acceptance of TA among political decision-makers (*original title*: Lernprozesse: Probleme der Akzeptanz von TA bei politischen Entscheidungsträgern)
(6) Bechmann, Gotthard (1992): Consequences, addressees, patterns of institutionalization and rationality: Some dilemmas of technology assessment. (*original title*: Folgen, Adressaten, Institutionalisierungs- und Rationalitätsmuster: Einige Dilemmata der Technikfolgen-Abschätzung)
(7) Petermann, Thomas (1992): Away from TA – but where to? (*original title*: Weg von TA – aber wohin?)
(8) Petermann, Thomas (1999): Technology assessment as policy advice (*original title*: Technikfolgenabschätzung als Politikberatung)

Renate Mayntz's (1986) essay (Chapter 5) on the acceptance of TA among political decision-makers is set in the context of the planning-optimistic paradigm of the 1960s and 1970s with its central assumptions of the state's high steering competence and the predictability of social developments through cybernetic models.

In her analyses of a more modern understanding of the state, the author deals with the role of TA in policy advice. She opposes TA as a scientistic-cybernetic instrument with which planning-optimistic ideas could ultimately be realized through TA. Such a rationalistic TA would not meet with acceptance in politics because political self-rationality – here one can sense the influence of systems theory (Luhmann 1984) – would not allow this. With reference to the functional differentiation of the state, Mayntz argues against under-complex ideas of TA as policy advice. Its acceptance and thus its sustainable success depend on the one hand on the presumed political implications of the results and on the other hand on adequate placement in the differentiated political system.

Today, planning optimism has been buried and TA is no longer geared toward the cybernetic support of overall state control. Nevertheless, Mayntz's analyses remain relevant. States around the world are regaining considerable control competencies, and cybernetic control optimism is returning in many areas due to digitalization and the AI euphoria. In these developments, the predictability of the world and its data- and model-based prediction have once again become an explicit goal, so to speak in a new guise, which many computer scientists in particular consider to be achievable. Mayntz's essay thus continues to encourage ongoing reflection on the relationship between the state, TA, and society and its changes.

In Chapter 6, *Gotthard Bechmann* (1992) comes to a sobering conclusion with regard to the cybernetic understanding of the consultative dimension, in which scientifically reliable knowledge of consequences is a prerequisite for effective management. After many prognostic failures, the once enthusiastically pursued futurology is no longer in vogue. With regard to the consultative dimension of TA in the political process, he refers, like Mayntz (in Chapter 5), to the structural discrepancy between the political and scientific systems (Luhmann 1984). In particular, the implementation of TA results encounters limits due to the necessity of evaluations. If TA results are politically unwelcome, they could easily be ignored with reference to the subjectivity of TA. There is a risk that decision-makers will only accept TA results if they converge with their own goals or preconceptions. TA would then be degraded to the legitimization of already existing positions. Bechmann rejects the repeatedly proposed normative abstinence that TA should withdraw to the role of a pure knowledge provider of value-neutral information with reference to the limits of instrumental reason according to critical theory. He also rejects the "elitist model" of policy advice, according to which a *Chief Science Advisor* or an academy of science, for example, could authoritatively prescribe these assessments.

According to Bechmann, the "participatory" negotiation model of TA remains closely related to the "pragmatist model" according to Jürgen Habermas (1968). In order to avoid problems caused by suspicions of subjectivity, Bechmann calls for an impact assessment that is "objectified" through transparency and criticality, similar to the concept of social epistemology (Longino 1990), which was presented at almost the same time. Overall, these analyses have triggered a wide range of debates on the values and normative dimension of TA, which are still enriching today (Nierling/Torgersen 2020).

Thomas Petermann (1992) sets a different accent in Chapter 7, "Away from TA – but where to?", originally published in the same book as Bechmann's Chapter 6. Petermann focuses on criticism from social science technology research and – to a lesser extent – from the philosophy of technology of the basic assumptions of TA, which attack the possibility of successful policy advice through TA based on the following: TA can only rationalistically feign its claimed objectivity; it is subject to a double determinism of technology; technology development is seen as an exogenous and quasi self-dynamic factor instead of considering technology genesis and technology as a social process; it has no eye for alternatives but sees technology consequences as determined by technology instead of developing a theory of technical change; and it is technocratic and affirmative instead of critical. This impressive list reflects the lively TA debate of the time.

The consequences that Petermann draws from this are still groundbreaking today: TA must abandon naïve technological determinism, but without succumbing to a voluntarism of arbitrary designability, it must overcome misunderstood claims of value neutrality and its "positivist hesitancy" and must take into account the cultural interdependencies of technology debates as well as the patterns of interpretation and cultural staging of technology contained therein (here one can see an early reference to hermeneutic TA, see Mehnert/Grunwald 2024). In addition, it must take technology seriously as a social process of genesis, use, and disposal, systematically learn from historical processes of technology assessment and deal with technological change and its influencing factors. In summary, TA should be "social assessment."

In a later article published in 1999 (Chapter 8), *Thomas Petermann* no longer focused on a lost role of the state as a central steering authority as in the steering debate, but on TA in new and more complex constellations of consultation. In the framing of the text, the shock wave of the closure of the OTA in the U.S. in 1995 is clearly recognizable, which ultimately represented a failure of consultative TA in the face of hard political realities (Bimber 1996). According to Petermann, it must be taken seriously that in TA as policy advice, two professions that are

profoundly alien to each other come together and that difficulties in cooperation are to be expected. It is absurd to assume that scientific knowledge can simply be transferred to politics and "applied" there. The consultative dimension of TA is not a simple transfer of knowledge, but a complex communication process consisting of the decontextualization of scientific TA results and their recontextualization in the political system. It is not simply "politics" that is the addressee of policy advice, as this does not even exist. Instead, the state itself is differentiated in many ways, both vertically and horizontally. It has also delegated many of its technology-related regulatory or promotional activities to other actors or levels, such as expert councils, commissions or authorities. With reference to Mayntz (Chapter 5), Petermann concludes that there can be no question of a resigned withdrawal of the state, but that it is not monolithic in itself, but rather highly diversified. TA is therefore still in demand as policy advice, but must be able to serve this political diversification in its consultative dimension.

Together, these four essays point out that the constellation of TA as both an advisor on the one hand and as the advisee in politics on the other is a constitutive element of TA. This is the central theme in the reflection on its consultative dimension. As part of science, TA is mandated to provide knowledge and reflections, but not to intentionally influence or technocratically determine the social or political debates and decisions based on them. The motivation to achieve an "impact" through advice, while at the same time preserving the freedom of the institutions mandated to make decisions and shape the future as "honest brokers" (Pielke 2007), is one of the balancing acts of TA (Grunwald 2019).

The transfer of scientific knowledge to non-scientific areas as well as the transfer of consulting needs to TA is not trivial in either direction. TA as an advisory practice requires a good knowledge of the working methods and world perceptions of its addressees, e.g., in parliaments, in order to make impact possible. Conversely, those being advised must be able to articulate a need for advice and be willing to be advised or, in Niklas Luhmann's language, "irritated" by TA as a science.

1.3 TA as communication and participation – the discursive dimension

Participation and discourse, the involvement of non-scientific social groups, and dialogue procedures are now standard in many TA research projects and advisory settings. Depending on the topic and objective, focus groups, dialogues, and citi-

zens' conferences are held with stakeholders, users, affected parties, or the general public. They are intended to generate knowledge for the technology assessment that cannot be gathered through purely scientific research, such as empirical knowledge, interests, values, fears, and wishes. Conversely, they are intended to provide information and understanding between TA and society and to prepare political decisions. However, participatory processes are also criticized in the TA community today for being too cost-intensive, and because their "impact" is not verifiable, the representativeness of the participants is hardly given, and the relevance of the results for political and scientific decisions in technology promotion, regulation, and development usually remains very uncertain (Böschen et al. 2021; Hennen 2012). In general, however, the necessity of the discursive-participative dimension of TA is not called into question.

Compared to the debates in the TA community in the 1980s and 1990s, participation and discourse have become more or less "normalized" today. Back then, there was a controversial discourse about the meaning and functionality of participatory and discursive processes. The historical background was the legitimacy crisis of the state and the public loss of trust in the authority of purely scientific expertise as a result of environmental crises, chemical disasters, and the nuclear accident at Chernobyl – generally in the course of the anti-nuclear movement and the increasing protests against genetic engineering releases. The importance of participation was discussed very substantially in the TA publications of the time. Today, the discussion within TA focuses more on problems in participatory procedures and how these can be overcome (Fuchs et al. 2018). If in that earlier time the participation of the population in TA analyses was discussed as a necessity for political decision-making in view of the state's legitimacy crises and the associated technology controversies, today the emancipatory and learning potential of participation seems to be in the foreground.

Overview of articles

(9) Paschen, Herbert (1975): Technology assessment as a participatory and argumentative process (*original title*: Technology Assessment (TA) als partizipatorischer und argumentativer Prozess)

(10) Hennen, Leonhard (1994): Technology controversies. Technology assessment as a public discourse (*original title*: Technikkontroversen. Technikfolgenabschätzung als öffentlicher Diskurs)

(11) Gloede, Fritz (1994): Technology policy, technology assessment, and participation *(original title*: Technikpolitik, Technikfolgen-Abschätzung und Partizipation)

(12) Bechmann, Gotthard & Gloede, Fritz (1992): Recognition and acknowledgement: A consideration of the limits to the idea of "early warning" (*original title*: Erkennen und Anerkennen. Über die Grenzen der Idee der "Frühwarnung")

In Chapter 9, *Herbert Paschen* (1975) defines TA as a scientific and advisory practice for anticipating and assessing, as systematically and comprehensively as possible, all effects (especially subsequent and unintended secondary and tertiary effects) of new technologies on all affected areas of society and the natural environment. His ideal flow chart for TA analyses was as follows: The first step is to define the problem and determine the assessment task. This is followed by the development of a comprehensive information base, which is the prerequisite for identifying, analyzing, and evaluating potential consequences. Based on this expertise, options for action are derived and, if necessary, direct recommendations for policy are made: This basic scheme still guides TA today. Paschen responded pragmatically to the criticisms of TA which were made at the time and are still known today (e.g., no demonstrable objectivity of future knowledge, value-laden and interest-driven results, unclear future relevance of the results, neutrality of the TA institution), and which could not be resolved even by the most perfect TA practice, by demanding the greatest possible transparency, process-accompanying public information, and ensuring a maximum of active, direct participation. This chapter devotes particular attention to the latter, as affected groups with little economic- and decision-making power should also be integrated into TA analyses and evaluations. Paschen derives options for the realization of direct participation, such as telephone statements or publicly accessible information databases. He characterizes the discursive-participative dimension of TA as an argumentative, open, and not only knowledge-generating process. In doing so, he laid the foundation for further justifications and critical discussions on participation and discourse, as presented in the following articles in this part.

Chapter 10 by *Leonhard Hennen* (1994) was originally published at the height of the technology controversies, in the 1990s, particularly with regard to green genetic engineering and participation debates. Hennen takes up the topic of state control and legitimation crises and the resulting technology controversies. His thesis is that discursive procedures of TA are to be understood as a reaction to public technology controversies and that their efficiency and rationality are based on this. He addresses the discursive-participative dimension of TA by classifying procedures of "discursive TA" as a necessary attempt to organize technology controversies in public discourses. He reconstructs their necessity with reference to Ulrich Beck's social diagnosis of the self-reflection of socially generated risks

and dangers in the "risk society" (1986), and Niklas Luhmann's thematization of the low resonance of ecological protest in political, scientific, and economic subsystems due to the lack of connectivity to the system-specific codes and programs in "Ecological Communication" (1990). In order to overcome the problem of resonance, Hennen justifies the necessity of organizing public discourse by providing participatory arenas on the part of TA. He sees this organization of discourse – following Jürgen Habermas' "Theory of Communicative Action" (1988) – as a necessary medium of social integration in view of the loss of public trust in scientific expert systems and the legitimation problems of state technology policy. Hennen illustrates the difficulties of successful discursive-participatory TA with the problems of the participatory TA project on the "Cultivation of crops with genetically engineered herbicide resistance" (1991–1993; Bora/van den Daele 1997) carried out at the Berlin Social Science Center (WZB). Despite all the unresolved problems of discursive TA, he emphasizes the creative potential of the discursive-participative dimension of TA, which is often underestimated. He describes expectations that participatory discourse will lead to consensus on highly controversial issues as highly unlikely. Thus, like Paschen (see Chapter 9), Hennen also justifies the discursive-participative dimension of TA, whereby the emancipatory potential that is more strongly discussed in TA today already resonates with him.

The challenges of participatory TA and the problems of the WZB procedure are also the subject of *Fritz Gloede*'s article (Chapter 11). This was also originally published in 1994, but with a focus on different expectations and often undifferentiated justification contexts for participation: Participation as a functional requirement for cognitive decision-making vs. participation as a democratic political demand vs. participation as an element of discursive mediation and social learning processes. Using the WZB procedure, Gloede shows how it was precisely the intermingled contexts of justification and conflicting expectations of industry representatives, genetic engineering critics, and the organizers that led to conflicts, and ultimately to the failure of the procedure (the withdrawal of NGOs critical of genetic engineering and genetic engineering releases by industry during the procedure). He also locates participation and discourse as a necessary, but not sufficient, condition for democratic technology control, and characterizes participatory TA as a primarily qualitative and argumentative process. For Gloede, as for Hennen (see Chapter 10), the procedural criticism of participatory TA (e.g., lack of representativeness of the participants, no quantifiable impact measurement) is not the central problem for the critical self-reflection of TA on

its discursive-participative dimension. Thus, he emphasized the emancipatory potential of participation very early on.

The final contribution to this dimension by *Gotthard Bechmann & Fritz Gloede* (1992) in Chapter 12, takes up the topic of TA as early warning, which also plays a role in the part on the risk dimension of TA (Sec. 1.1), in relation to the necessity of participation. As already emphasized in the part on the consultative dimension of TA (Sec. 1.2), Bechmann & Gloede focus on early warning of technical hazards and risks as a basis for the timely recognition and assessment of future environmental problems that are not yet visible as a knowledge base for the state's duty to take precautions in accordance with the precautionary principle introduced in the 1990s. Based on Niklas Luhmann's theory of functional differentiation of subsystems of society (Luhmann 1984), the authors work through the problems of translating TA knowledge into information relevant for political decisions. According to Bechmann & Gloede, the potential dangers of new technologies that are not yet visible at the time of the assessment are not per se relevant information for the political system in terms of decision-making and regulation. These concerns could only become relevant for political precautionary decisions through public participation, organized by TA by means of discursive-participative procedures on even vague dangers (not yet calculable as regulation-relevant risks in the sense of classic risk assessment). In this way, political decisions can represent the public interest of their electorate in accordance with their system-specific selection conditions. This contribution thus brought a new aspect of the discursive-participative dimension of TA to the fore, namely that TA knowledge can only become policy-capable and preparatory for decision-making through public participation. Nowadays, this reflection can hardly be found in scientific debates on TA and related scientific practices, although the problems of translating TA research results into decision-oriented knowledge for politics have by no means disappeared.

Compared to these reflections on the discursive-participative dimension of TA, which were strongly grounded in social theory, the debate today has narrowed to questions of procedural and process optimization. But even if the points of criticism and socio-theoretical contextualizations of participation and discourse put forward at the time seem to be below the radar of TA today, this does not mean that the problems and challenges identified at the time can be considered as solved and overcome – i.e., that everything is just a question of process optimization. The influence of TA expertise on political decisions is often uncertain (despite the direct institutionalization of policy advice, e.g., by the TAB) (e.g., Grunwald 2019). In contrast to the 1980s and 1990s, however,

participation and discourse are no longer much discussed as a necessity for overcoming state decision-making and legitimacy problems, but are increasingly seen as a medium for enlightening and emancipating the public – participation as a collective learning process of all social groups involved has come to the fore.

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

Looking at the wealth of literature that has considered TA as "a specifically different form of science" (Böschen et al. 2021, p. 15) in recent decades, it is admittedly difficult to discover a common thread with regard to a coherent theory development within the framework of TA. However, such a development was not planned in the genesis of TA. The history of TA shows, as all authors in the "history of theory" agree, that since the 1960s there has been an increasing need for critical reflection to advise politics and society in order to avoid negative consequences for society. The role, functions, and position(s) of TA in the context of societal debates subsequently became complex and influenced the design of innovative scientific directions (Böschen et al. 2021). Nevertheless, or perhaps precisely for this reason, a process of self-reflection in TA began in the 1990s, which describes central positions, but also areas of tension, both externally and internally, which have hardly lost their topicality to this day. What is more, it seems that these reflections on TA's own work in those years were driven by a certain urgency, not least because TA was confronted with various kinds of causes and resistance from both science and politics. This style characterizes the seven selected contributions in this final part of the volume: Here, a search movement is indicated which, in view of the technically-induced problem situations in society, formulates possible certainties, but also the contradictions of TA and puts them up for discussion. This reveals a view of theoretical-conceptual premises that was to become constitutive for TA in its further course. Against this backdrop, it still seems incredibly inspiring to devote oneself to these contributions from the 1990s, given the current state of debates in TA.

Overview of articles:

(13) Paschen, Herbert & Petermann, Thomas (1992): Technology assessment: A strategic framework for the analysis and evaluation of technologies (*original title*: Technikfolgen-Abschätzung: Ein strategisches Rahmenkonzept für die Analyse und Bewertung von Techniken)

(14) Dierkes, Meinolf & Hähner, Katrin (1999): Concept development of technology assessment: Review and outlook (*original title*: Konzeptentwicklung von Technikfolgenabschätzung: Rückblick und Ausblick)
(15) Gethmann, Carl Friedrich (1999): Rational technology assessment (*original title*: Rationale Technikfolgenbeurteilung)
(16) Grunwald, Armin (1998): Technology assessment – between sociological systems theory and philosophical ethics (*original title*: Technikfolgenabschätzung zwischen soziologischer Systemtheorie und philosophischer Ethik)
(17) Grunwald, Armin (1996): The epistemological status and cognitive limits of technology assessment (*original title*: Erkenntnistheoretischer Status und kognitive Grenzen der Technikfolgenabschätzung)
(18) Bechmann, Gotthard & Frederichs, Günter (1996): Problem-oriented research: Between politics and science (*original title*: Problemorientierte Forschung: Zwischen Politik und Wissenschaft)
(19) Gloede, Fritz (1992): Rationalization or reflexive scientification? On the debate about the functions of technology assessment for technology policy (*original title*: Rationalisierung oder reflexive Verwissenschaftlichung? Zur Debatte um die Funktionen von Technikfolgen-Abschätzung für Technikpolitik)

The history of the emergence of TA is constitutive for the methodological design of TA and still ensures that TA has a firm place at the interface between society (politics) and science. The first three articles in this part, all describe the "concept development" of TA, which goes back to the 1960s. During this period, people in the U.S. became increasingly aware of the consequences of technical and scientific progress in the form of catastrophes and undesirable consequences and thus became the subject of public debate. U.S. politicians reacted with a report which, among other things, called for the establishment of an "early warning system" to identify the negative and positive consequences of technological applications. The term technology assessment was officially used for the first time in this report. There were similar developments in many European countries, which are considered by Paschen & Petermann and Dierkes & Hähner. As a policy-related information instrument, TA was institutionalized in many European countries in the subsequent decades. According to *Meinolf Dierkes & Katrin Hähner* (1999) in Chapter 14, the social consensus on technological progress became fragile during these years, as described in almost all the articles in this part, that the assumption that technical and social progress are in a linear, directly proportional relationship to each other has lost much of its trust. Due to this situation, institutional

forms had to be found that could provide a systematic assessment of technologies with regard to social developments. Dierkes & Hähner formulate relevant proposals such as iterative analysis circles in the assessment of socio-technical problems or technology genesis motivated by social science, which is beneficial from today's perspective, as many of these aspects were pursued further in TA.
Against a similar background, but already with some initial experience of TA as an advisory institution at the German Bundestag, in Chapter 13 *Herbert Paschen & Thomas Petermann* (1992) proposed strategic instruments quite early on that should be implemented as part of a reflexive design of socio-technical systems. As important ideal premises of this design, they mention, among other things, the claim of "early warning" of technology impacts, the decision orientation of TA, and the inclusion of problem-oriented knowledge with regard to technical programs. These topics are still being discussed intensively today as part of the epistemic knowledge canon of TA (Böschen et al. 2021).

The contribution by *Carl Friedrich Gethmann* (1999) in Chapter 15 is somewhat different, recognizing that TA should be regarded as an interdisciplinary cross-sectional task of the science system, but that TA is largely integrated into the political system and thus its scientific nature suffers considerably. Against this background, he opposes TA with the concept of "rational technology assessment" and argues primarily for a rational obligation to justify statements and the need to justify actions. He develops his remarks with the statement that technology assessment must be measured not by factual acceptance, but by the normative acceptability of decisions, which itself can only be (laboriously) determined in social processes. In the end, however, Gethmann concedes that it is not demarcation, but rather a fruitful dialogue between the two approaches that is crucial in order to work out the complementarity of both concepts. Interestingly, the description of rational technology assessment corresponds exactly to what is often carried out today with the inclusion of applied ethics in TA studies, be it in the field of energy transition, robotics, or other topics (Grunwald/Hillerbrand 2021).

The next two contributions follow on from Gethmann in disciplinary terms, but open up the space to explore the conceptual framework of TA. In Chapter 16, *Armin Grunwald* (1998) responds to the theoretical approaches of systems theory, which, based on the work of the sociologist Niklas Luhmann, reached a high point in social science debates in the 1990s (Luhmann 1984, 1990). The difference between system and environment introduced by Luhmann as well as the paradigm of closed self-referential systems, which no longer allows control of the overall system, affects the scope of action of TA to a large extent. Prior

to this interpretation, ethics was also declared largely obsolete for technology issues, whose system-analytical argumentation logic Grunwald vehemently contradicted in this article. He calls for the practical relevance of technology ethics to be understood in concrete cases by (also) incorporating the system-theoretical diagnosis of current societies. For example, the scientific treatment of concrete social consequences of technology from the point of view of knowledge and advice is necessary in order to clarify the relationship to ethics in individual cases and to offer solutions. In the end, however, it is not the determination of a blockade to action that is functional, but rather the question of whether society can decide whether and how it considers drawing technical boundaries. The challenging answers to many open questions in the relationship between society and technology lead to the constitutive characteristics of the self-description and self-understanding of modern societies, which an epistemologically committed TA must face up to. In view of this expectation, Grunwald argues that ethics should be integrated more than ever into existing or newly established practices of technology design. It is important not to start from a control center of society, but to use ethical reflections where conflict situations (can) arise. Chapter 17, the second contribution by *Armin Grunwald* (1996), also touches on the debates mentioned above. Before the assumption of closed social systems, each with their own functional logic, human actions were explained in system-theoretical approaches as operations that take place solely via "acts of communication" (Luhmann 1986, p. 269). This led to the assumption that in TA too, the relevance of cognitive problems is increasingly devalued in favor of communication problems in the TA process or the implementation problem (Luhmann 1986), which would be tantamount to an enormous loss of significance of TA. Grunwald counters this thesis by proposing a distinction between the scientific study of cognitive problems of technology assessment *and* the communication of these results. Only when scientific results, i.e., scientifically reliable results of TA, are available would their communication to the outside world and the implementation of these results become relevant. Against this background, the epistemological status of TA must be brought into focus, struggled for, and ultimately developed. As an example, he then discusses topics that are still relevant today, such as the justification of TA statements from an epistemological perspective.

The final two articles in this part (critically) reflect on specific aspects of TA that have become constitutive for TA theory formation. Chapter 18, "Problem-oriented research: Between politics and science" by *Gotthard Bechmann & Günther Frederichs* (1996) is now considered a "classic" of TA. The authors agree with the diagnosis of intensive debates in the 1990s, which were conducted under the

concept of "post-normal science" (Funtowicz/Ravetz 1993). This diagnosis states that a functional change is taking place in the relationship between science and politics, which began with the Manhattan Project[3] in the U.S. during World War II, but only came to fruition in the 1990s in view of complex social problems such as environmental pollution and the (controversial) organization of the welfare state. A new type of problem-oriented research emerged, which developed new research structures in the face of complex social problems. However, Bechmann & Frederichs concede that the old impetus of wanting to achieve better policy with the means of science remains. In light of these developments, new expectations were placed on science not only to provide specialist knowledge, but also to make predictions about future events that needed to be prevented. The authors identified TA as a prototype of this form of knowledge and thus moved TA close to the field of science, without neglecting the advisory role of TA. On the contrary, they defined the framework of TA as "problem-oriented research" and defined framework conditions including differentiation parameters from basic research and the necessity of inter- and transdisciplinarity. These aspects as developed and critically discussed in this article are still part of the theoretical dimensions of TA today.

Chapter 19 by *Fritz Gloede* (1992) theoretically refers to the debates on a "reflexive modernity," which were particularly characterized by the sociologist Ulrich Beck in the 1990s (Beck/Bonß 1998). Gloede addresses technically-induced social problems that – despite great political and scientific efforts – cannot be solved. The ambivalent structural dynamics of technological developments (Grunwald 2019) persist, and the problems that continuously arise from them (temporal, factual, social) cannot be solved even by TA. Gloede therefore argues that TA should be recognized as both subject and object within the framework of a "reflexive scientification" (Beck/Bonß 1989, p. 29). At the level of problem situations *and* at the level of social and societal problem perceptions, a self-enlightened TA concept should refer to itself in a doubly reflexive way. This means that TA is both an observer and a participant and should always reflect this dual role in its work. This is an assessment that has already been formulated by Grunwald (see Chapter 16) and to a large extent contains the expectation of developing theoretical-conceptual frameworks for TA. Gloede goes on to discuss aspects that describe TA as problem-oriented research with which TA must deal reflexively

3 The Manhattan Project was a U.S. research and development program during World War II to produce the first nuclear weapons. It was carried out in collaboration with the United Kingdom and Canada.

and continuously: The concept of technology, the concept of consequences, and the advisory concept in which TA operates. He summarizes that a reflexive and self-reflective view of TA brings forth various problems of the concept of consequences that need to be taken into account. In principle, however, technology development as social mechanization must always be understood as a social strategy whose normative and factual implications must be taken into account.

The articles selected for this book show that already in the 1990s, premises, basic requirements, but also many methodological uncertainties were placed on TA, which are still highly topical today – despite changing framework conditions. Moreover, these basic requirements have shaped TA in the further development of its theoretical foundation. A look at these debates today shows that the topics dealt with in these articles have become anchored and further developed as theoretical premises of TA.

2. Conclusion and outlook

In 2022, the "Limits to Growth" study (Meadows et al. 1972) reached its fiftieth birthday. From today's perspective in particular, the study is considered a milestone in the awareness of the economic, technical, and ecological consequences of the future, which were caused in particular by Western industrialized countries. Other technically-induced events followed, such as the poisoning accident in Bhopal, India, in 1984 and the reactor accident in Chernobyl, Ukraine, in 1986, which became engraved in people's collective memory. For the first time, these events caused deep cracks in the belief in scientific and technological progress, which stood as a guarantee for social prosperity. As the selected articles in this volume show, TA emerged precisely in this social and political environment. First in the U.S., and shortly afterwards in Europe, there was a call for institutions to analyze and evaluate the far-reaching problems of the relationship between society and technology and to make this orientation knowledge available to political decision-makers. Technically-induced crisis phenomena, i.e., the "risks" of technological progress, can therefore be seen as the birth of TA. From the very beginning, the challenges facing TA were enormous. The articles in this volume point this out. TA, which was located at the interface between politics and science, had to quickly develop a profile. This was achieved by developing the strategic framework conditions for its advisory role, but also by successively developing methodological framework conditions for generating scientific expertise in many technical fields and, based on this, advising initially political and

later also other stakeholders. Against this background, the 1990s can certainly be seen as a decade of the TA search movement, a search movement in which TA often had to defend itself against external "hostility." The selected articles tell of this search movement, of tentative experimentation, and of a constant learning process, in which TA certainties emerged that are still valid today, but at the same time new questions were raised that TA is still dealing with now.

The selection of articles was made jointly by the editors, and provided much cause for discussion and – in retrospect – for renewed appreciation of the contributing authors. Firstly, many topics that are now part of the TA canon were substantiated and passionately demanded and defended by the contributing authors during this period. Secondly, topics were discussed that were subsequently conceived as theoretical contributions to TA, but are still being negotiated today as open and methodologically relevant questions. Thirdly, the articles are characterized by an intensive culture of debate in which the topics are presented with professional expertise and personal commitment. Prominent scientific debates of the 1990s are incorporated into the articles and form the blueprint for the respective argumentation logics. From today's perspective, this is very enlightening and makes it clear how and in what way conceptual ideas in TA have evolved.

We, the editors, wish that the interested readers of this volume also experience these moments of amazement, of remembering, of learning and, above all, the desire to participate in the future field of TA.

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