Science Advice to Parliaments: The Office of Technology Assessment at the German Bundestag

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ABSTRACT: Technology assessment (TA) emerged over 50 years ago as a scientific approach for analyzing and evaluating the consequences of technology. The main reason for this was the increasing awareness of negative consequences of technology. Parliamentary TA originated in the US Congress. Since the 1980s, it has been established in many European parliaments. This article describes the work of the Office of Technology Assessment at the German Bundestag. It reflects on the experiences gained in over 30 years of existence. A clear distinction between scientific and political mandates has proven to be central to the well-functioning of parliamentary policy advice.

KEYWORDS: technology assessment; anticipation; inclusion; pragmatism; policy advice; science/policy interface

1. Technology Assessment in the Ambivalence of Technology

Technology assessment (TA) is neither an invention of science nor of engineers. Rather, it was created in the form of parliamentary TA by politicians in the US Congress.[1] One of its fathers was the legendary US Senator Edward Kennedy in the 1970s. The background to its invention was the contemporary diagnosis of the ambivalence of technological progress, which has been confirmed and exacerbated to this day, for example in the climate crisis and the ambivalent consequences of digitalization.

Since the Industrial Revolution at the latest, and increasingly in recent decades, technical progress has become as inevitable as it is problematic. *Inevitable* because innovation and competitiveness require new

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[1] B.BIMBER, *The politics of expertise in Congress: the rise and fall of the Office of Technology Assessment*, New York, 1996.

technologies, for example in digitalization or in biotechnologies, but also because the transition to a more sustainable and climate-friendly society is inconceivable with today's technologies. Technical progress is *problematic* because experience shows that it usually has not only desired but also unintended consequences, some of which are surprising and often undesirable and negative, such as climate change or the threat to public communication posed by *social media* and AI. This experience of a profound *ambivalence* of technology, the technological advance, and further technicalization forms the central background of TA.[2]

Until the 1960s, optimism about progress was dominant, beginning with the European Enlightenment, focusing on technical progress during the Industrial Revolution, and flourishing in the industrialized countries of the East and West after World War II. Technical progress seemed possible without limits, as evidenced by the utopian expectations of an energy-rich society in the vision of the "atomic age" of the 1960s. Environmental crises, the arms race during the Cold War, persistent development problems in the Global South, and the limits of growth and the climate crisis, which has been worsening for decades, have profoundly challenged this optimism. In some cases, they have led to the opposite, with dystopian expectations of the future currently dominating Western societies. The negative consequences of technology and technologization point to the price that often has to be paid for progress . The gap between the intended positive consequences of technology on the one hand and the unintended, often negative consequences on the other, leads to uncertainty about further technological progress , to problems of orientation in political action, and to social conflicts.

Therefore, it is necessary to take a forward-looking approach to the possible consequences of technology in all its diversity in order to enable well-informed and reflective decisions. This is precisely where TA comes in. It uses scientific methods to respond to the need for guidance from politics and society in order to support responsibly shaping the technological advance and the use of its outcomes. Its fundamental goal is to contribute to shaping the future in and through technological progress. Three main areas of practice have emerged in TA over the last few decades:[3]

- Technology assessment as scientific advice to political institutions addresses publicly relevant and politically decisive aspects of technology, such as safety and environmental standards, the guarantee of human and civil rights, or the setting of priorities in research funding and technology policy.
- Technology assessment to support public debate and opinion-forming systematically involves citizens and stakeholders in debates about future technology, often involving the mass media, and sees itself as an element of deliberative democracy.
- Technology assessment as part of technology development accompanies research and development of technology in universities and industry. Knowledge about consequences is directly incorporated into the development of technology, e.g., to design technology according to values such as sustainable development.

These fields of practice are all concerned with analyzing, evaluating, weighing, and comparing the consequences and implications of technology across the entire spectrum of alternatives under consideration in order to identify the best possible solutions. The cognitive interest of TA consists in

[2] A. GRUNWALD, *Technology Assessment in Practice and Theory*, Abingdon, 2019.
[3] A. GRUNWALD (ed), *Handbook of Technology Assessment*, London, 2024.

"supporting, strengthening, and enhancing reflexivity in all epistemic and social fields of reasoning and decision-making on shaping the scientific and technological advance, on the usage of its outcomes, and on dealing with the consequences for present and future society". [4]

According to this, increasing reflexivity manifests itself in three dimensions.[5] First, it consists of a broader view of future technological consequences in spatial, temporal, and thematic terms. Technology assessment therefore relies on *anticipation*. It requires knowledge of possible, plausible, or probable developments in connection with new technologies, including possible unintended consequences. Then, comparisons and considerations can be made to support informed and reflective opinion-forming in politics and society.

Secondly, the profound impact of technological progress on human life and the emergence of possible unintended consequences make it necessary to integrate different value perspectives into the assessment. *Inclusion* is intended to increase the legitimacy of decision-making processes and the robustness of the results. Participatory technology assessment enables greater reflexivity with regard to values and interests in connection with technology and its consequences.

Thirdly, technology assessment requires reflective complexity management for both anticipation and inclusion. Despite excessive complexity, concrete projects must cope with limited resources and be carried out within a limited time frame without losing sight of essential aspects of the issue at hand. This is primarily a matter of transparency, traceability, and justification with regard to necessary distinctions of relevance.

Since shaping the future is fundamentally linked to values like ideas about the good life or about a just society, it cannot be optimized using scientific models. Instead of referring to data and facts, normative reflection on values and goals is essential. Therefore, TA is not concerned with data-based scientific optimization of paths to the future, but with opening up and exploring *possible* paths to the future based on different values and goals. This is intended to support lively social debate and democratic decision-making with knowledge and orientation. This understanding, which corresponds to the role of *the honest broker*,[6] contrasts technocratic approaches of optimization with *thinking in terms of alternatives*.

2. Parliamentary Technology Assessment

The term "technology assessment" was coined in the US Congress in the mid-1960s. The *Office of Technology Assessment* (OTA) was the world's first TA institution, established in 1972 by the Technology Assessment Act[7] to advise the US Congress on research and technology decisions. The reasons for its establishment lie, on the one hand, in the growing awareness of the ambivalence of technology , the rise of the environmental movement, and the emergence of areas of tension and conflict surrounding modern technology and unintended consequences. This was enshrined in the OTA's founding act:[8]

The Congress hereby finds and declares that:

[4] A. GRUNWALD, *Technology Assessment in Practice and Theory*, cit.
[5] A. GRUNWALD, *Technology Assessment in Practice and Theory*, cit.
[6] R. F. PIELKE, *The Honest Broker: Making Sense of Science in Policy and Politics*, Cambridge, 2007.
[7] *United States Senate,* Technology Assessment Act. Report of the Committee on Rules and Administration, Washington, D.C., 1972.
[8] *United States Senate*, *op. cit*.

(a) As technology continues to change and expand rapidly, its applications are large and growing in scale; and increasingly extensive, pervasive, and critical in their impact, beneficial and adverse, on the natural and social environment.
(b) Therefore, it is essential that, to the fullest extent possible, the consequences of technological applications be anticipated, understood, and considered in determining public policy on existing and emerging national problems.

On the other hand, the US Congress was increasingly concerned about the democratic principle of separation of powers between the legislative and executive branches. The executive branch, i.e., the president and departments, had considerable financial and human resources and full access to scientific knowledge. It was gaining an ever-increasing advantage over Congress in terms of taking technical progress into account. The second motivation for establishing the OTA was therefore democratic in nature: to strengthen Parliament by creating its own scientific advisory capacity.

According to the Act, the OTA's main tasks included technology assessment, the development of alternative solutions and the assessment of the associated consequences, as well as an explicit advisory mandate. The most important criterion for the organizational design of the OTA was to ensure neutrality.[9] The OTA was not to be instrumentalized by political parties, external interest groups, or lobbyists from industry. To this end, a sophisticated system of committees was established to monitor each other and ensure neutrality. Politics took precedence in determining the topics to be addressed. The Technology Assessment Board, which exercised parliamentary oversight, set the agenda and was composed of equal numbers of Republicans and Democrats.

The OTA's gradually evolving working style has served as a model for TA to this day. Information gathering and initial analysis were outsourced to external contractors, often universities, through the commissioning of expert reports. This allowed the OTA to focus on bundling, integrating, and action-oriented evaluation of knowledge for Congress. Its work was accompanied by reviews, hearings, and workshops, some of which involved social groups.

The OTA was the first coherent institution to provide guidance for politics and society in dealing with the ambivalences and tensions of technology, progress, and the consequences of technology. This made it a reference point for the TA that emerged in the 1970s and occasionally beyond. The end of the OTA in 1995 was brought about as part of the "neoconservative revolution" proclaimed by Republican majority leader Newt Gingrich when the Republican Party gained a majority in both the House of Representatives and the Senate after the 1994 elections.[10] The parliamentary TA in the US then found a new home in a department of the General Accountability Office (GAO).[11]

The emergence of TA in the US was closely watched in Western countries, as they faced similar challenges. The parliamentary orientation of the OTA had a particularly significant impact. In the German Bundestag, a debate on the introduction of a German OTA took place as early as 1973, albeit without any initial

[9] B. BIMBER, *op. cit.*
[10] B. BIMBER, *op. cit.*
[11] T. PERSONS, *Technology Assessment in the United States: reinvention and reinvigoration*, in: A. GRUNWALD (ed.), *Handbook of Technology Assessment*, London, 2024, 163-173.

results. In the 1980s, the first parliamentary TA institutions were established in Europe, for example in Denmark, the United Kingdom, the Netherlands, and France:[12]

In the early 1980s, on the occasion of a number of debates such as the orientations concerning nuclear, spatial or "cable" programmes, Parliament came to the conclusion that it was unable to evaluate the Government's decisions on the major directions of scientific and technological policy. It therefore decided to endow itself with its own assessment structure: the Parliamentary Office for Scientific and Technological Assessment.

Since then, the number of parliamentary technology assessment (TA) institutions has been slowly increasing, initially in Europe and gradually also internationally. The *European Parliamentary Technology Assessment Network* (EPTA)[13] was founded in 1990 to promote European networking. The founding members include the British *Parliamentary Office of Science and Technology* (POST), the German TAB (see below), the Dutch Rathenau Institute, the *Norwegian Board of Technology (*NBT), the French *Office Parlamentaire d'Evaluation des Choix Scientifiques et Technologiques* (OPECST) and the *Scientific and Technological Options Assessment (*STOA) of the European Parliament.[14] The EPTA currently has thirteen full members and twelve associate members. The latter are mostly from non-European countries such as South Korea, Japan, Chile, and Mexico, as well as the US after the OTA was dissolved. EPTA's most prominent activity is an annual conference that serves as a forum for European and international exchange on current TA issues, particularly with parliamentarians from different countries.

3. The Office of Technology Assessment at the German Bundestag (TAB)

The *Office of Technology Assessment at the German Bundestag* (TAB) was established in 1990 to improve the information base for parliamentary decision-making processes, particularly those related to research and technology.[15]

3.1. Tasks

The TAB's range of tasks is closely modeled on that of the OTA. Its main tasks include designing and implementing technology assessment projects on various topics and monitoring and analyzing important scientific and technological trends and related social developments (monitoring). The central criterion for selecting topics is that scientific and technological progress has consequences for political fields of action. On the one hand, new options for innovation, the labor market, sustainability, health, mobility, competitiveness, or security, etc. may emerge whose use requires political action, e.g., through research and innovation funding. On the other hand, there are often challenges to regulation in order to safeguard human and civil rights, for example in the digital transformation or in relation to environmental and health

[12] OPECST - *Office Parlementaire d´Evaluation des Choix Scientifiques et Technologiques, Self description*, 2017, www.eptanetwork.org/members/full-members/france (last visited 09/03/2026).

[13] www.eptanetwork.org (last visited 09/03/2026).

[14] More information can be found at: POST (www.parliament.uk/mps-lords-and-offices/offices/bicameral/post1/); Rathenau (www.rathenau.nl/en); NBT (teknologiradet.no/en/homepage/); STOA (www.europarl.europa.eu/stoa/en/home/highlights) (last visited 09/03/2026).

[15] See for all the details of this section: T. PETERMANN, A. GRUNWALD, *Technikfolgen-Abschätzung am Deutschen Bundestag*, Berlin, 2005.

standards. Promotion through public budgets and the creation of attractive framework conditions for innovation on the one hand, and regulation and setting limits on the other, are the classic fields of action for the state. In many cases, there is a need for scientific advice on both sides, including in parliaments.
Another area of consulting that has become highly relevant since the COVID-19 pandemic and Russia's attack on Ukraine is the security of critical infrastructure. Modern societies depend on the smooth functioning of technology, especially supply infrastructures such as energy, water, health, food, and data communication. The results of a project for the German Bundestag on the consequences of a long-lasting and supra-regional power blackout in Germany were alarming:[16] numerous deaths would be expected after just a few days. Digitalization exacerbates dependencies, on the one hand because of potential systemic risks, whereby small causes can lead to system instability through complex chains of events and positive feedback loops, and on the other hand because they become vulnerable to cyberattacks.
In response to this situation, the TAB implemented a new analysis scheme in 2023, the Resilience Radar. It shall identify trends that could pose systemic risks and challenges for critical infrastructures, with a view to deriving measures to increase resilience. The first report examined the infrastructure systems of energy, agriculture and food, and transport and mobility.[17]
In addition to its specific project work for the German Bundestag, the TAB's tasks also include science communication to promote public dialogue on technology and its consequences, the further development of the range of TA methods, and networking with the European TA community, especially within the framework of the above-mentioned EPTA network.

3.2. Institutional Setting

The TAB is neither an institution of the German Bundestag nor an independent institution. Rather, the operation of the TAB is awarded to an external research institution for a period of five years. Every five years, a public announcement is made and a call for tenders is issued for the operation of the TAB for the next period. The contract is awarded on a competitive basis. Since 1990, the TAB has been operated by the Institute for Technology Assessment and Systems Analysis (ITAS) at the Karlsruhe Institute of Technology (KIT), with different concepts and often with different partners.
Between the German Bundestag and the operator for the operation of the TAB, a contract is concluded which regulates obligations and rights and, in particular, the use of the budget provided by the Bundestag. In particular, the contract stipulates that the scientific advice provided to the German Bundestag must be based on the principles of scientific independence and ideological neutrality. The head of the TAB is responsible for this and, within the scope of this management activity, is not subject to the instructions of the operator, currently the Presidium of the Karlsruhe Institute of Technology. This is to prevent the operator from misusing the TAB for lobbying on its own behalf.
The TAB is therefore not administratively subordinate to the administration or politics of the German Bundestag, but is part of an independent scientific institution. This is important in order to enable scientific independence (see below). The proximity to political events and the alignment of the advice

[16] T. Petermann, H. Bradtke, A. Lüllmann et al., *What happens during a blackout. Consequences of a prolonged and wide-ranging power outage*, Berlin, 2011.
[17] N. Bledow, M. Eickhoff, M. Evers-Wölk et al., *Foresight-Report 2024 — Ergebnisse der Analysen aus dem Resilienz-Radar*, Berlin, 2024.

with the needs of the Bundestag are guaranteed by the contract and the specific work processes implemented on the basis of this contract. A constitutive feature of the institutional structure of the TAB is thus the combination of its proximity to the Bundestag and its advisory needs with the principle of scientific independence (see section 4.2 below).

3.3. Mode of Operation

The TAB is strictly oriented toward the information needs of the German Bundestag and its committees. The TAB's direct client is the Committee on Education, Research, and Technology Assessment. It decides on the TAB's main areas of work and projects, even if these arise from suggestions made by other committees or political groups represented in the Bundestag. The direct interface between the TAB and the committee is provided by the TA rapporteurs, one person from each of the political parties represented in the Bundestag, supported by the secretariat of the Research Committee.

The parliament is responsible for identifying, specifying, and narrowing down the topics for TA projects. This is because setting the agenda is clearly a political rather than a scientific act. Decisions on the urgency of project topics and the scientific advice required belong on the political agenda. Contrary to the usual democratic majority principle, a consensus requirement applies to the selection of topics. This is to prevent the majority factions from suppressing the topic requests of the minority. This consensus requirement is thus reminiscent of the original idea behind parliamentary TA, which was to strengthen the parliament vis-à-vis the executive branch. Different from the US American political system, the executive branch automatically constitutes the majority in the committees in Germany.

In concrete terms, a topic selection process takes place approximately every 18 months. First, all committees and parliamentary groups are invited to submit topics they would like to see addressed in the next period. In recent rounds, the number of requests received has usually been between 40 and 50, significantly more than the number of projects (around 12) that can be handled with the TAB's resources. This wish-list is then analyzed by the TAB according to scientific criteria, practical considerations, and available resources. On this basis, the TAB draws up a proposal for the portfolio of topics for the next period. This is discussed politically and approved by the Committee under requirement of consensus, which sometimes leads to thematic shifts and adjustments.

Occasionally, preliminary studies are carried out at the TAB prior to the actual TA investigations. The purpose of these studies is to provide an initial review of the state of knowledge and to examine *possible* research designs, questions, objectives, etc. in a transparent, comprehensible, and targeted manner. The Parliament then has the opportunity to refine the topic and the scope of the respective TA project on the basis of this transparent review and the TAB's proposals.

The topics specified by Parliament in this way are dealt with by the TAB *in a scientifically independent and neutral manner* (see below). The diversity of existing inquiries and topics is addressed by obtaining expertise from scientific institutions with the necessary specialist knowledge on the subject matter of each project. These inputs are evaluated by the TAB team, focused on the parliamentary advisory needs, and compiled in a report to Parliament. As a rule, alternative courses of action are developed for political decision-makers, especially the *Bundestag*, and their implications and consequences are discussed.

In most cases, it is possible to present the results orally to the Research Committee, to relevant other committees, or to working groups of the political parties. This networked approach allows the relevant

expertise and knowledge of the scientific system to be mobilized on a case-by-case and topic-specific basis for the decision-making purposes of Parliament. TAB projects are formally concluded with approval by the Research Committee, i.e., recognition that the TAB has fulfilled the obligations set out in the commission. This approval does not imply any political evaluation of the project's messages. The political debate on the content, the evaluation due to political values and positions, and the discussion on possible actions to be taken comes after this approval only and is separated from TAB's project work.

3.4. Impact

Since the TAB was established, more than 200 reports have been prepared for the German Bundestag. The topics cover a wide range. Examples include space travel, nanotechnology, the change in political communication brought about by the Internet, the consequences of a prolonged power blackout, medical innovations for Africa, climate engineering, addictive behavior in connection with electronic media, care robotics, the results of the annual switch between winter and summer time, the future of the world of work in the age of digitalization, the digitalization of agriculture, increasing the resilience of decision-making structures through a crisis radar, autonomous weapon systems, bibliometric data in identity documents, prospects for nuclear fusion for energy supply, the consequences of ChatGPT for education, forest conversion in times of climate change, and the consequences of the widespread introduction of working from home. All reports are available on the TAB website[18] in full text and as summaries, the latter mostly also in English language.

In particular, numerous topics from the fields of life sciences, biotechnology, and medical technology were addressed, such as gene doping, synthetic biology, the potential of bacteriophages, stem cell research, preimplantation diagnostics, individualized medicine, and genetic editing. There are often thematic overlaps and cooperation with the fields of bioethics and health technology assessment (HTA). HTA refers to the evaluation of medical technologies, taking into account their safety, clinical effectiveness, costs and cost-effectiveness, impact on quality of life, and legal, ethical, and social implications, usually as advice for health insurance companies and health authorities.

The results of these studies have varying consequences. Occasionally, they are used directly for Bundestag decisions. For example, the study on nanotechnology led the Bundestag, initiated by the Research Committee, to call on the federal government in 2003 to promote research into nanotoxicology in order to gain knowledge about possible health risks posed by nanomaterials. The study on the consequences of a long-lasting blackout of the electricity supply[19] led to a critical review of all civil protection and disaster control areas affected and to measures to improve the protection of citizens and public infrastructure. The study on the impact of the annual switch between summer and winter time took an interesting turn. It was forwarded to the European Parliament by the Christian Democrats via their membership in the European People's Party. There, in 2019, it led to the abolition of Central European Summer Time (CEST), however, subject to an agreement by the EU member states on a common time schedule.

Most studies have a more indirect impact on parliamentary opinion-forming and decision-making processes. This is particularly true when analyzing the potential and consequences of new technologies at an early stage of development, when political parties first have to develop their own positions. The TAB

[18] Online:www.tab-beim-bundestag.de (last visited 09/03/2026).

[19] T. Petermann, H. Bradtke, A. Lüllmann et al. *op. cit.*

therefore often acts less as a direct decision-making support and more as a guide for emerging issues and new technologies.
Plenary debates in the Bundestag play an important role in this regard. TAB reports have repeatedly been used as source material for such debates, for example on food waste and data mining. Parliamentary or public expert workshops also serve to familiarize participants with and discuss alternative options for the future. The latter also serve to communicate science to the broader public. Other areas of impact include the reception of TAB studies by other target groups. Ministries, authorities, and funding agencies with a particular interest in the topics regularly study TAB reports in order to draw conclusions for their own work.

4. Theoretical Background

TA emerged as a consulting practice in parliaments and was not derived theoretically.[20] This took place against a specific philosophical and democratic theoretical background (4.1). The design of the interface between science and politics is a subject of particular theoretical interest (4.2).

4.1. Pragmatist Approach to Policy Advice

Technology assessment emerged in Western democratic societies. It was introduced and developed as an instrument of democratization, for example to strengthen parliaments vis-à-vis the executive branch, as in the US OTA and the German Bundestag. In participatory TA, the normative goal is not to leave the shaping of scientific and technological progress and the handling of its consequences to institutionalized politics or techno-economic elites, but to demand and practice the substantial participation of citizens and stakeholders in the spirit of inclusion.
TA was accompanied by a Western-oriented, democratic understanding of society. American philosopher John Dewey proposed a model of a modern and democratic society,[21] which was taken up by Jürgen Habermas to develop his model of a pragmatist relationship between science, politics, and the public.[22] This model has clear consequences for scientific policy advice, which have had a major influence on the history of TA, particularly with regard to its normative basis and its relationship to democracy.[23]
Dewey starts from a liberal view of citizens in modern society, guided by the idea of human rights as enshrined, for example, in the US Constitution. His basic observation is that human actions have indirect consequences that can affect the rights and freedoms of others. Dewey regards the regulation of these indirect consequences as the main task of politics, while the shared awareness of these indirect consequences, in his view, constitutes "the public". In accordance with the normative foundations of liberalism and human rights, he introduces democracy as a combination of the regulation of indirect consequences and the normative expectation that everyone should be involved:[24]... democracy is the

[20] A. GRUNWALD, *Technology Assessment in Practice and Theory*, cit.
[21] J. DEWEY, *The public and its problems*, New York, 1927.
[22] J. HABERMAS, *Toward a Rational Society*, London, 1970.
[23] T. SARETZKI, *Habermas, critical theory and public policy*, in F. FISCHER, D. TORGERSON, A. DURNOVA ET AL. (ed.), *Handbook of Critical Policy Studies*, Cheltenham, 2015.
[24] J. DEWEY, *op. cit.*, 147.

regulation of the public interest arising from indirect consequences and related conflicting interests; it is combined with the idea that everyone should be involved and, in principle, regarded as a person capable of co-deciding about a regulation of such indirect consequences.

This approach can be directly applied to dealing with the unintended consequences of scientific and technological progress, including the need for scientific policy and social advice:[25] An intelligent public debate into indirect consequences – as public concerns – and their regulation is needed, which requires support from scientific experts as well as transparency in public affairs.

Dewey's ideas were elaborated and further developed by Jürgen Habermas with regard to the relationship between politics, the public, and science. According to Habermas, it is necessary "that, on the one hand, scientific experts "advise" the decision-making authorities and, conversely, that politicians "commission" scientists according to practical needs. TA is an example of this two-way communication between politics and science.

However, in line with Dewey's position, institutionalized scientific policy advice should only play a *preparatory role* for a consultation process that is ideally carried out by the "public of citizens", or, as we would say today, in civil society. Habermas called this model "pragmatist" in contrast to technocratic and decisionist ideas. It became a fixed point of reference in TA and has been increasingly implemented in participatory forms since the 1980s.

The pragmatist model is clearly based on normative and counterfactual assumptions about how society *should be* organized, how decision-making processes *should* take place, and that the "coercive force of better arguments" (Habermas) *should* prevail. However, everyday practice in TA is by no means characterized by communication free of domination or power play. On the contrary, it is at the center of controversies and power struggles, can become a pawn in conflicting interests, has to deal with lobby groups, is not independent of party political constellations, and has a precarious existence in the parliamentary sphere.

However, this does not invalidate or even render obsolete the normative orientation of TA toward democracy in the pragmatist sense. Rather, it results in the imperative to improve the empirical conditions in line with the normative orientation. By dealing with technological consequences in a transparent, argument-driven, and reflective manner, TA also contributes to improving the conditions for its own possibility. The normative model of pragmatist policy advice serves as an ideal for identifying deficits, voicing criticism, and exploring and implementing improvements.

Much has changed since Dewey and Habermas' reflections: globalization, the information society, sustainability, the crisis of democracy, the rise of authoritarian regimes, and populism even in core democratic countries are relevant keywords. This naturally affects the conditions for implementation and empirical facts, which are countered by technology assessment based on democratic theory. Even if the core of the normative foundations remains unaffected, it is nevertheless important to take these changes seriously and, if necessary, expand the theoretical foundations of TA.[26] Critical voices[27] argue that theorists of deliberative democracy turn a blind eye to power politics. This could undermine democratic

[25] J. Dewey, *op. cit.,* 167.

[26] P. Delvenne, C. Parotte, *Technology assessment and democratic theories: a critical review*, in A. Grunwald (ed.): *Handbook of Technology Assessment*, London, 2024, 259-269.

[27] C. Mouffe, *Agonistics: Thinking the World Politically*, London, 2013.

politics. For TA, taking the agonistic elements of democracy seriously can mean taking action in times of democratic crisis instead of waiting and distant observation:[28]
TA cannot remain neutral when democracy comes under pressure. In this respect, TA must be, in the terminology of Roger F. Pielke, an issue advocate in favor of democracy.

4.2. On the Relationship Between Acience and Politics at TAB

A common problem in scientific policy advice is that one side, whether science or politics, encroaches on the other. For example, politics may believe that it can order convenient results, or science may believe that it can make policy itself through policy advice. Both lead to disappointment and frustration. Policy advice must take the different mandates of science and politics seriously.
The relationship between politics and science varies in parliamentary TA institutions.[29] In the French OPECST, for example, the primacy of politics, which uses science for its own purposes, is evident in the fact that the leadership of the OPECST is reserved for politicians from the Senate and the National Assembly. On the other hand, the Dutch Rathenau Institute has a rather loose connection to politics, as evidenced by the fact that this institute belongs to the Royal Academy of Sciences, which stands for scientific independence.
In the German TAB, scientific advice and targeted policy have been institutionally separated in order to enable scientifically independent advice while ensuring its connection to political advisory needs. To this end, a corresponding governance system has been established, for example, whereby the identification of topics is reserved for politicians (see above). This prevents the TAB from dealing with topics in which the Bundestag has little or no interest.
In this science/policy interface, the mandates of science and politics are separate. Science has the mandate to provide knowledge in scientific independence, while politics has the mandate to evaluate knowledge and draw practical consequences. This separation takes into account that the future must be shaped *politically*, i.e., according to values, goals, and social ideas, and is not an object of scientific optimization. This results in the task of scientific advice to provide policymakers with options for action, but not recommendations for a scientifically optimal path. This model, also based on US pragmatism, has been summarized in the following metaphor:[30]
... researchers, together with stakeholders, act as the "cartographers" of different, viable policy pathways and their practical consequences by acting as the "mapmakers" of the future. They provide a guidebook with alternative options for policymakers (i.e., the "navigators") and the public. Such maps cannot replace traveling, i.e., decision-making, nor can they resolve all environmental policy conflicts, yet they can provide important orientation in otherwise uncharted territory.
Parliamentary TA is therefore about supporting politicians in making better informed and more reflective decisions *based on their own rationality*. To this end, it is the task of advisory science to identify *options* for viable paths to the future, for example on the energy transition or digitalization, and to enrich these

[28] P. Delvenne, C. Parotte, *Breaking the myth of neutrality: TA has politics, TA as politics*, in *Technological Forecasting and Social Change,* 139,2019, 64–72.
[29] M. Nentwich, *Parliamentary Assessment Institutions and Practices*, Vienna, 2016,
[30] O. Edenhofer, M. Kowarsch, *Cartography of pathways: A new model for environmental policy assessment*, in *Environmental Science and Policy*, 51, 2015, 63.

with scientific information such as costs, risks, and potential conflicts. The decision on which path to take in the future is reserved for democratically legitimized institutions. German sociologist Niklas Luhmann described this form of advice as "irritation":[31] through its proven knowledge, science creates irritation among the political recipients of the advice. They, in turn, use this as food for thought to determine paths to the future enriched by the advice and, if necessary, to implement them in accordance with their political rationality.

Terms such as neutrality and independence are central to this model of parliamentary consultation. They were already central to the OTA in the US Congress: "OTA was designed to emphasize both the appearance and reality of non-partisan, neutral competence".[32] Insofar as TA institutions work for parliaments and are financed with public funds, their obligation to impartiality is evident:[33]

What is specific about POTAs (parliamentary offices of technology assessment, A.G.), as part of their identity, are the neutral, independent, and non-partisan values of the information and policy analysis they produce, values built on traditional Mertonian scientific exceptionalism.

Scientific independence encompasses related or partly synonymous, but also partly differently used terms such as neutrality, impartiality, objectivity, or balance.[34] The demand for independence (or balance, impartiality, etc.) in scientific policy advice is based on the difference between the advisor and the person being advised: advisors should enrich decisions , but not dominate or even determine them. However, given the generally high level of politicization of the subject areas of TA, e.g., nuclear energy , genetic engineering , or medical technology, and the impossibility of strictly separating facts and values, it is a challenge to demonstrate scientific independence. To this end, the line of argumentation and the process leading to the results of a TA project must be traceable step by step. The postulate of transparency is therefore of overarching and central importance: "Demand for transparency , traceability, and verifiability of TA processes: assumptions and value judgments should be disclosed".[35] Trust in parliamentary TA institutions is based largely on the fulfillment of this requirement.

5. Practical Experiences

It was difficult to establish TA as an institutional body within the German Bundestag. Two Bundestag commissions dealt with this issue in the 1980s. When the TAB was finally founded in 1990, there was considerable skepticism, particularly among experts. Many expected this experiment to fail fairly quickly. The opposite has happened. The TAB has now been in existence for 35 years. It has survived several changes of majority in parliament as well as different government coalitions. It has repeatedly changed its thematic priorities and offerings in line with social developments. For example, innovation was the

[31] N. Luhmann, *Die Wissenschaft der Gesellschaft*, Frankfurt, 1990.
[32] B. Bimber, *op. cit.*, 50.
[33] L. Cruz-Castro, L. S-Menendez, *Politics and institutions: European parliamentary technology assessment*, in *Technology Forecasting and Social Change*, 27,2004,79–96.
[34] A. Grunwald, *Scientific independence as a constitutive part of parliamentary technology assessment*, in *Science and Public Policy*, 33, 2006, 103–113.
[35] *COMMITTEE – Ausschuss für Bildung, Forschung und Technikfolgenabschätzung, Beratungskapazität Technikfolgenabschätzung beim Deutschen Bundestag – ein Erfahrungsbericht. Berlin, Bundestags-Drucksache* 14/9919, 2002, 6.

dominant theme in the 2000s, followed by sustainable development in the 2010s, followed by digitalization and AI. Currently, as mentioned above, the vulnerability and resilience of critical infrastructures is a major topic.

The projects and products have also changed. Whereas comprehensive projects and voluminous reports of several hundred pages were the norm in its early days, the TAB has become more agile over the last 10 years and has introduced short formats to meet the political need for rapid information. While an active role for the TAB in science communication was initially not desired by politicians, this has changed completely in recent years, with the result that the TAB now offers more services to the public.

It is interesting to note that the institutional setting established in 1990 has remained largely unchanged during these adaptation processes. The model used at the time has proven its worth in several respects:

- the commissioning of a research institution independent of the German Bundestag to operate the TAB has ensured its scientific independence
- the model's separation of the mandates of science and politics and the clear definition of their interfaces (see above) has prevented encroachment from either side and enabled productive cooperation
- limiting the TAB's mandate to five years, followed by a new call for tenders, has helped the TAB to become a learning and adaptive organization with a high degree of flexibility over the decades of its existence
- the consensus principle has ensured that the TAB prepares studies for the entire Bundestag, not for individual parties. This has prevented party-political failures such as those experienced by the American OTA.

These experiences explain why the TAB model has been successful for so long and can continue to be so. However, there are challenges to be overcome:

- after each new election to the German Bundestag, around 60% to 80% of the members of the committees are new and are usually completely unfamiliar with the TAB. This means that the TAB has to make itself known again after each election and rebuild trust in its work.
- with a few exceptions (e.g., the aforementioned blackout study), the public visibility of the TAB and its projects and reports is rather low. One reason for this could be that the balance of projects desired in the TAB model, which are intended to represent the entire Bundestag, limits its attractiveness for media coverage, as the mass media tend to be more interested in polarizing statements.
- a persistent challenge in the TAB's daily work is to maintain and secure the attention of parliamentarians in the face of fierce competition for attention.

In contrast, the widespread crisis of democracy and the rise of populist parties have not yet had a negative impact on the TAB in the German Bundestag, unlike in some other European countries. For example, the most recent mandate for its operation, given in 2023, was approved unanimously, so that there is a clear new mandate for the current contract period. Parliamentary TA is and remains fragile and vulnerable in principle, however.