Technology Assessment and Design for Values

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Abstract

Technology assessment (TA) constitutes a scientific and societal response to problems at the interface between technology and society. It is a field that has arisen against the background of various experiences concerning the unintended and often undesirable side effects of science, technology, and societal technicization. This chapter provides an overview of the history, motivations, objectives, and present status of TA. Elements of the governance of technology are discussed in order to identify appropriate constellations where knowledge and orientation provided by TA could be used to improve decision making. There are three major branches of TA: TA as policy advice (e.g., to parliaments), TA in public debate (e.g., by participatory measures), and TA for shaping

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technology directly (e.g., by constructive technology assessment or by *Leitbild* assessment). In all of these branches, TA is considering relations between technology and values. In particular, insofar as TA is involved in processes of shaping technology directly, there is a close neighborhood with Design for Values.

Keywords
Ambivalence of technology • Side effects • Innovation • Risk • Technology conflicts • Policy advice

Introduction and Overview

Technology assessment (TA) constitutes an interdisciplinary research field aiming at, generally speaking, providing knowledge for better-informed and well-reflected decisions concerning new technologies. Its initial and still valid motivation is to provide answers to the emergence of unintended and often undesirable side effects of science, technology, and technicization (Bechmann et al. 2007). TA shall add reflexivity to technology governance by integrating any available knowledge on the side effects at an early stage in decision-making processes, by supporting the evaluation of technologies and their impact according to societal values and ethical principles, by elaborating strategies to deal with the uncertainties that inevitably arise, and by contributing to constructive solutions of societal conflicts. Values play a crucial role in all of these fields. There are three branches of TA addressing different targets in the overall technology governance:

1. TA has initially been conceptualized as *policy advice* (Bimber 1996), and still many TA activities are located in this field (Grunwald 2009a). The objective is to support policymakers in addressing the abovementioned challenges by implementing political measures such as adequate regulation (e.g., the precautionary principle), sensible research funding, and strategies toward sustainable development involving appropriate technologies. In this mode of operation, TA does not *directly* address technology development but considers the *boundary conditions* of technology development and use.
2. It became clear during the past decades that citizens, consumers and users, actors of civil society, stakeholders, the media, and the public are also engaged in technology governance in different roles. Participatory TA developed approaches to involve these groups in different roles at different stages in technology governance (Joss and Belucci 2002).
3. A third branch of TA is related more directly to concrete technology development and engineering. Departing from analyses of the genesis of technology made in the framework of social constructivism (Bijker et al. 1987) the idea of *shaping technology* due to social expectations and values came up and motivated the development of several approaches such as constructive TA (CTA) or social shaping of technology (Yoshinaka et al. 2003). They all aim at increasing

reflexivity in technology development and engineering by addressing the level of concrete products, systems, and services, going for a "better technology in a better society" (Rip et al. 1995).

All these branches of TA have to deal with social values and ethical reflection. In this chapter, I will introduce briefly all these three branches but will then focus on the third one in order to identify sources of the idea of Design for Values. At the beginning the overall motivations of TA will be presented (section "Motivations of Technology Assessment") and a brief insight into technology governance will be given (section "Elements of Technology Governance"). Section "Technology Assessment: Adding Reflexivity to Technology Governance" is dedicated to explaining the very idea of TA for increasing reflexivity in technology governance which will be done briefly with respect to the three branches of TA mentioned above. More in depth I will then look at approaches of TA which explicitly address technology development and design, such as the constructive TA and the social shaping of technology approach (see section "TA Approaches Relevant for Design for Values").

Motivations of Technology Assessment[1]

In the twentieth century, the importance of science and technology in almost all areas of society (touching on economic growth, health, the army, etc.) has grown dramatically. Concomitant with this increased significance, the consequences of science and technology for society and the environment have become increasingly serious. Technological progress alters social traditions, fixed cultural habits, relations of humans and nature, collective and individual identities, and concepts of the self while calling into question traditional ethical norms. Decisions concerning the pursual or abandonment of various technological paths, regulations and innovation programs, new development plans, or the phasing out of lines of technology often have far-reaching consequences for further development. They can influence competition in relation to economies or careers, trigger or change the direction of flows of raw materials and waste, influence power supplies and long-term security, create acceptance problems, fuel technological conflict, challenge value systems, and even affect human nature (Habermas 2001).

Since the 1960s also adverse effects of scientific and technical innovations became obvious; some of them were of dramatic proportions: accidents in technical facilities (Chernobyl, Bhopal, Fukushima), threats to the natural environment (air and water pollution, ozone holes, climate change), negative health effects as in the asbestos case, social and cultural side effects (e.g., labor market problems caused by productivity gains), and the intentional abuse of technology (the attacks on the

[1]This section follows the introduction to TA given in Grunwald (2009a). Some paragraphs were taken from that chapter and adapted in a shortened way.

World Trade Center). The experience with such unexpected and serious impacts of technology is central to TA's motivation. Indeed, in many cases, it would have been desirable to have been warned about the disasters in advance, either to prevent them or to be in a position to undertake compensatory measures. This explains why the methodologically quite problematic term "early warning" with regard to technological impacts (Bechmann 1994) has always had a prominent place in TA discussions from the very beginning (Paschen and Petermann 1992, p. 26).

Early warning is a necessary precondition to make societal and political *precautionary action* possible: how can a society which places its hopes and trust in innovation and progress, and must continue to do so in the future, protect itself from undesirable, possibly disastrous side effects, and how can it preventatively act to cope with possible future adverse effects? Classic problems of this type are, for example, the use and release of new chemicals – the catastrophic history of asbestos use being a good example (Gee and Greenberg 2002) – and dealing with artificial or technically modified organisms (for further examples, cf. Harremoes et al. 2002). In order to be able to cope rationally with these situations of little or no certain knowledge of the effects of the use of technology, prospective precautionary research and corresponding procedures for societal risk management are required, for instance, by implementing the precautionary principle (von Schomberg 2005; Grunwald 2008).

Parallel to these developments, broad segments of Western society were deeply unsettled by the "Limits of Growth" (Club of Rome) in the 1970s which, for the first time, addressed the grave environmental problems perceived as a side effect of technology and technicization. The optimistic pro-progress assumption that whatever was scientifically and technically new would definitely benefit the individual and society was questioned. As of the 1960s deepened insight into technological ambivalence led to a crisis of orientation in the way society dealt with science and technology. Without this (persistent!) crisis TA would presumably never have developed.

New and additional motivations entered the field of TA over the past decades, leading more and more to a shift toward "shaping technology" according to social values (and, therefore, building a bridge to the idea of Design for Values):

- Issues of democracy and technocracy or of democratizing technology (von Schomberg 1999): from the 1960s on, there are concerns that the scientific and technological advance could threaten the functioning of democracy because only few experts were capable of really understanding the complex technologies. The technocracy hypothesis was born painting a picture of a future society where experts would make the decisions on the basis of their own value systems. One of the many origins of TA is to counteract this possibility and to enable and empower society to take active roles in democratic deliberation (Joss and Belucci 2002; Grunwald 2003).
- The experience of technology conflicts, of legitimacy deficits, and of little acceptance of some decisions on technology motivated TA to think about more socially compatible technology. The very idea was to design technology

according to social values – and if this would succeed, so the hope was, problems of rejection or nonacceptance would no longer occur. This line of thought seems to be one of the sources of Design for Values (see section "TA Approaches Relevant for Design for Values").

- In the past decade the innovation problems of Western societies influenced also the motivations and driving forces of TA. TA was considered part of regional and national innovation systems (Smits and den Hertog 2007) which could contribute to "responsible innovation" and "responsible development" (Siune et al. 2009) by taking into account not only technical and economical but also social and ethical aspects.
- Shift in the societal communication on new and emerging science and technology (NEST): techno-visionary sciences such as nanotechnology, converging technologies, and synthetic biology entered the arena. Visions and metaphors mark the expected revolutionary advance of science in general and became an important factor in societal debates. To provide for more rationality, reflexivity, and transparency in these debates, vision assessment was proposed (Grunwald 2009b) as a new TA tool addressing not directly the assessment of *technologies* but rather the assessment of *visions* (Grin and Grunwald 2000). In particular, vision assessment aims at reconstructing normative elements of the visions under consideration including inherent values.
- Finally, recent debates around ethics in the field of biomedicine (e.g., stem cell research, xenotransplantation, and reproduction medicine) led to a convergence of applied ethics and TA in some regard and complemented the agenda of TA by issues of bioethics and medical ethics.

Compared to the initial phase of TA, a considerable increase of its diversity and complexity can be observed. In modern TA, it is often a question not only of the consequences of individual technologies, products, or plants but also frequently of complex conflict situations between enabling technologies, innovation potentials, fears and concerns, patterns of production and consumption, lifestyle and culture, and political and strategic decisions. The challenge of "responsible innovation" (Siune et al. 2009) can be seen as a core to which all of these research and assessment branches contribute, setting out from different premises, using different perspectives, and applying different TA methodologies (see section "TA Approaches Relevant for Design for Values").

Elements of Technology Governance

Technology is being shaped and influenced in a complex process of technology governance (Aichholzer et al. 2010). TA shall "make a difference" in this process – and in order to be "really" able to make a difference, TA must have sound knowledge about the processes of technology development and diffusion, about the pathways from research to innovation, about social integration and adaptation of new technology, about influencing and decisive factors in these processes, and so

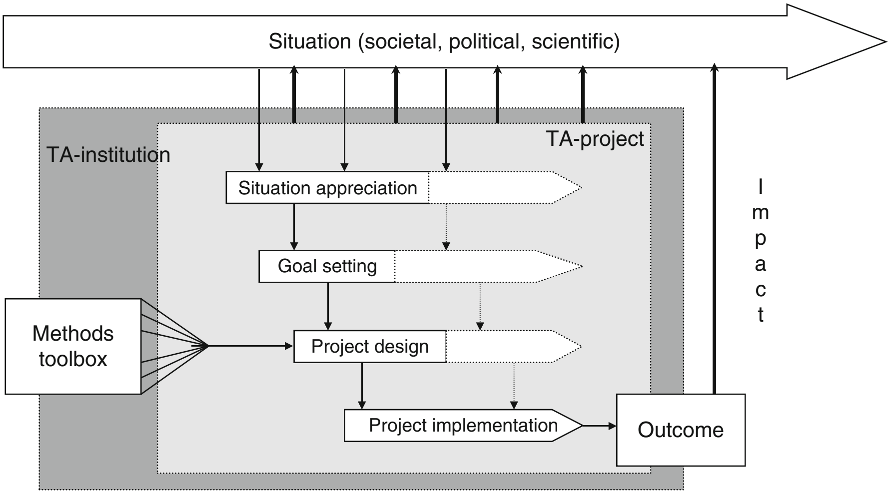

Fig. 1 TA influencing the ongoing societal situation by concrete TA projects continuously keeping track with developments at the societal level (Decker and Ladikas 2004)

forth. In the TAMI project (Decker and Ladikas 2004), the very idea of TA in making a difference was conceptualized in the following way (Fig. 1):

A complete picture of all the possible entry points of technology assessment would require a complete theory of technology in society. Such a theory would have to include theories of the origin and genesis of technology, the route technology takes through society during the phase of its utilization, and the manner in which society deals with a technology after its use is discontinued – this would probably be no less than a comprehensive theory of society which is not available. Regarding this situation, I will restrict myself to briefly describing important elements of the overall technology governance and of relevant actors.

Governance of science (Siune et al. 2009) as well as the governance of technology has become much more diverse and complex over the past decades. While in earlier times (in the "classical mode" of TA, cp. Grunwald 2009a) a strong role of the state was supposed, nowadays much more actors and stakeholders are regarded as being influential on the development and use of new technologies: companies, consumers, engineers, nongovernmental organizations (NGO), stakeholders of different kinds, and citizens. Depending on their roles and occasions to take influence, the advice provided by TA could or should look different – in this sense the shift from "steering technology" to a "governance of technology" has had a major influence on TA. Theories of technology development and governance could provide orientation for TA whom to address and what to deliver.

However, the political system remains a major player since public research and technology policy create legitimate and binding decisions with (partially) high influence on technology. Policy consultation by TA can, for example, take place in the preparatory phase of legislation relevant to technology or even in the very early phases of opinion forming in the political parties. In the run-up to policy decisions, it is possible for TA to carry out enlightenment by reflecting on possible consequences and impacts of technology on society and on the values touched (Grunwald 2003). This positioning of TA research and consultation affects all constellations in which state action influences technology including:

- Direct state-run or at least state-dominated technology development, for example, in the fields of space travel, military technology, and transportation infrastructure
- Indirect political influence on technology by means of programs promoting research and technology, for example, in materials science, on regenerative sources of energy, or in stem cell research
- Indirect political control of technology by setting boundary conditions such as environmental and safety standards, laws on privacy, or laws stipulating recycling
- The role of the state as a *user* of technology, e.g., with regard to the observance of sustainability standards (public procurement) and to its capability to create or support lead markets for innovative developments

TA gives advice to policymakers in all of these fields and to the involved organizations such as parliaments, governments, and authorities. An example is the *Office of Technology Assessment* at the German *Bundestag* (TAB: http://www.tab-beim-bundestag.de). TAB improves the legislature's information basis, in particular, of research- and technology-related processes of parliamentary discussion. TAB performs this mission in scientific independence (Grunwald 2006). Among its responsibilities are, above all, drawing up and carrying out TA projects, and – in order to prepare and to supplement them – observing and analyzing important scientific and technical trends, as well as societal developments associated with them (monitoring). The TAB is strictly oriented on the German *Bundestag's* and its committees' information and advice requirements. The subjects of the TAB's studies stem from all fields of technology and its applications such as energy, bio-, and genetic engineering; defense technologies; nanotechnology and materials research; space flight; medical technologies; and information and communication technologies.

The concrete development of technology and innovation, however, takes place primarily in the economy at market conditions. The shaping of technology by and in enterprises is operationalized by means of requirement specifications, project plans, and strategic entrepreneurial decisions. These in turn take place on the prescriptive basis of an enterprise's headline goals, general principles, plan goals, and self-understanding but also including assumptions about later consumers and users of the technology as well as future market conditions. Engineers and engineering scientists have influence on decisions at this level and are confronted in a special way with attributions of responsibility because of their close links with the processes of the development, production, utilization, and disposal of technology (Durbin and Lenk 1987; van Gorp 2005). Technology assessment became aware of the importance of this part of technology governance in the 1980s in the course of the social constructivist movement leading to the slogan of "shaping technology" (Bijker and Law 1994).

The individual preferences of users and consumers of technical systems and products help determine the success of technology developments in two ways: first, by means of their purchasing and consumer behavior and, second (and less noted), by means of their comments in market research. The influence on technological development resulting from consumer behavior arises from the concurrence of the actual purchasing behavior of many individual persons. A well-known problem is, for example, that awareness of a problem with regard to the deficient environmental compatibility of certain forms of behavior – though definitely present – may not lead to a change in behavior. Technology assessment aims, in this field, at public enlightenment and information about consequences of consumer's behavior and at enabling and empowering individuals to behave more reflexively.

The course of technical development is also decided by public debates, above all by those in the mass media. Public discussion in Germany influenced, for example, political opinion on atomic energy, thus providing much of the basis for the decision in 2002 to phase out atomic energy quickly in that country and to return to this position after a short, more positive appraisal of nuclear energy within hours after the Fukushima disaster. Similarly, the public discussion about genetically modified organisms has influenced the regulatory attitude of the European Union and the official acceptance of the precautionary principle (von Schomberg 2005). This can also be recognized by the fact that different regulations were established in those countries in which the public debates were very different, such as in the USA. Many of the public debates conducted in the media have also influenced the policy framework with indirect influence on technology. Technology assessment agencies have become an actor also in this field by involving themselves in participatory processes that play an increasing role in political decision-making processes in many countries.

These brief remarks should give some insights into the complex nature of technology governance – implying a similar complexity of technology assessment aiming at giving advice to actors in the various fields of technology governance. In the following, three fields of importance in and for TA will be described in some more detail: (a) TA as policy advice, (b) TA supporting public debate, and (c) TA aiming at shaping technology directly.

Technology Assessment: Adding Reflexivity to Technology Governance

Different TA approaches have been proposed and practiced responding to the societal context and to elements of technology governance, e.g., participative TA (Joss and Belucci 2002), constructive TA (CTA, Rip et al. 1995), interactive TA, TA relying on innovation systems research (Smits and den Hertog 2007), and others. On the one hand the differentiation is due to different questions each of them is suited to address; on the other it is due to different basic distinctions and

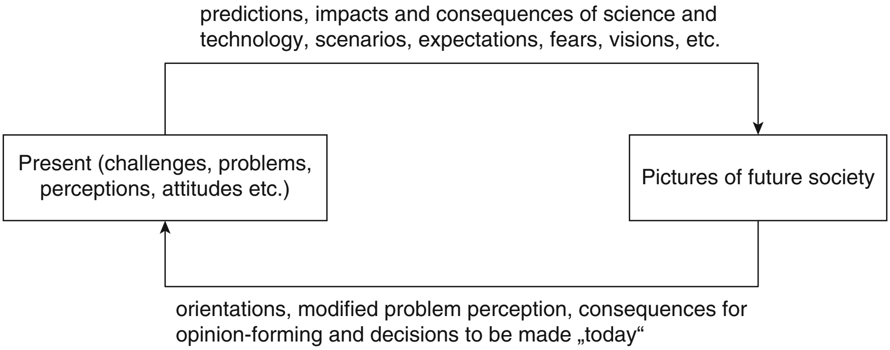

Fig. 2 The decision-making cycle via future thinking (Grunwald 2011)

assumptions about technology governance which relate directly to images and models of the technological evolution, the role of the state or the market in modern societies, how shaping of technology should work in democracies, etc. In this section I would like to demonstrate that there is a common element of TA beyond its diversity: the impetus to increase reflexivity in technology governance.

The theory of "reflexive modernization" (Beck 1986) stated, among other works on theory of modern society, that information gained from reflection on the future is a commonly used means for facilitating the decision-making process. Prospective knowledge of consequences, prognoses of technical progress, expectations, and fears, as well as aims, serves to provide orientation *today* for pending decisions (cf. Fig. 2). Proceeding from *present-day* problem perceptions, grand challenges, and expectations, orientation *for today* is sought via the roundabout route of debates about the *future*.

To provide orientation by reflecting on futures is a highly ambitious undertaking. For this to succeed, the loop of decision making (see Fig. 2) may not be a vicious circle, i.e., an idle state of knowledge, but must demonstrate added value that provides orientation compared to the situation *prior to* entering the cycle (cp. Grunwald (2011) for the case of energy futures). TA is in charge of contributing to constructively meeting this challenge in different fields.

TA for Policy Advice: The Case of Parliaments

Parliamentary TA is part of TA with a tradition of decades and with diverse forms of institutionalization (Vig and Paschen 1999; Cruz-Sastro and Sanz-Menendez 2004). It is about advising parliamentary actors within the frameworks based on the respective structures of the nation-state. In order to be able to analyze the role of parliamentary TA for technology governance, we have to take a closer look at the general role of the state in technology governance first. Obviously the provision of policy advice can be purposive, sensible, and effective only under the assumption that political actors and institutions play at least a rather important role in the overarching processes of technology governance.

However, this precondition is controversial. Traditional nation-states frequently are regarded as having lost their scopes for steering other actors like industry, supranational institutions, actors of civil society, or informal and nonhierarchical processes. Their remaining role would only be the role as a moderator of societal processes of communication. There is some evidence in this position but it does not justify the very far-reaching conclusions. Also in modern and less hierarchically structured societies, the democratic state with its institutions and procedures remains the sole place to produce legitimized, generally binding decisions. Of course this also applies for decisions, which concern technology and which are binding for all (cf. Grunwald 2000a).

The undoubted fact that technology and innovation development is definitely mainly taking place in the industry under market conditions does not exclude or diminish the relevance of political influence on technology. In a thought experiment we could distinguish between different aspects of technological products or systems: aspects bound to political reasoning (environmental norms, safety regulations, technical standardizations, general statutory provisions, etc.) and aspects which could be delegated to market developments. The relation between both may differ in the individual cases: the difference will be much bigger in ethically and politically relevant questions than in the optimization of the marginal benefit of established technologies. Policy-advising TA only covers technology aspects which are subject to policy, like the safety and environmental standards, the protection of citizens against encroachment on their civil rights, the setting of priorities in research policy, the definition of framework conditions for innovations, etc. This is exactly where the largest part of policy-advising TA is taking place.

Parliamentary TA as a subcategory of policy-advising TA presupposes that parliaments play a crucial or at least an important and relevant role in technology governance: necessary assumption is *that parliamentary action is relevant for technology governance*. It is obvious that this assumption is facing problems since the role of parliaments in democratic decision processes is often categorized as declining, sometimes as hardly noticeable any more. The possibilities of parliamentary TA are limited not only by the restricted role of the state in technology governance but also by the restricted role of parliaments in the distribution of power in democratic systems. If TA is institutionalized in parliaments, its influence also depends on the respective institutional setting. In an analysis of the roles of parliamentary TA in technology governance based on a theory of institutions, a variety of possible combinations of different institutional configurations occurs (Cruz-Castro and Sanz-Menendez 2004), which is also enriched by the characteristics of the democratic institutions of a nation-state and various political traditions (Vig and Paschen 1999).[2]

[2]There is a lively and growing community of parliamentary TA in Europe which has organized itself in the European Parliamentary Technology Assessment (EPTA) Network.

TA in Public Debate: Conflicts and Participation

Conflicts are characteristic of decisions in the field of technology, while consensus tends to constitute the exception. Making decisions in such conflict situations often results in *problems of legitimization* because there will be winners (who profit from specific decisions) and losers. This is frequently the case when decisions must be made about the site of a technical facility such as a nuclear power plant, a waste disposal plant, or a large chemical production plant. Depending on the selected location, people in the direct neighborhood will have to accept more disadvantages than others. Problems of legitimization always surface when the distribution of advantages and disadvantages is unequal.

In view of the decades of experience with a number of very serious acceptance problems and certain grave conflicts over technology, it has become clear that the question of legitimization is obviously important. Many examples can be given such as opposition to nuclear power, the problem of expanding airports, establishing new infrastructure elements such as highways or railway connections, the problem of how to dispose of radioactive waste, the release of genetically modified plants, the Strategic Defense Initiative ("Star Wars," SDI), and regional and local conflicts on waste disposal sites, waste incineration plants, and the location of chemical processing facilities. In these areas, political decisions are sometimes not accepted by those affected or by the general public, even though they are the result of democratic decision-making procedures. Conflict regulation and prevention are of the highest importance and a subject also to TA in its history.

Since the very beginnings of TA, there has been repeated demand for participative orientation, frequently following normative ideas from the fields of deliberative democracy or discourse ethics (Barber 1984; Renn and Webler 1998). According to these normative ideas, assessment and evaluation of technology should be left neither to the scientific experts (expertocracy) nor to the political deciders (decisionism) (see Habermas 1970 for this distinction). It is the task of participative TA to include societal groups – stakeholders, affected citizens, nonexperts, and the public in general – in assessing technology and its consequences. In this manner, participative TA procedures are deemed to improve the practical and political legitimacy of decisions on technology. Such TA is informed and advised by science and experts and, in addition, by people and groups external to science and politics (Joss and Belucci 2002).

The participation of citizens and of those affected is believed to improve the knowledge basis as well as the values fundament on which judgments are based and decisions are made. "Local" knowledge, with which experts and decision makers are often not familiar, is to be used in order to achieve the broadest possible knowledge base and to substantiate decisions. This discernibly applies especially to local and regional technological problems, in particular, to questions of siting. Furthermore, in a deliberative democracy, it is necessary to take the interests and values of ideally *all* those participating and affected into consideration in the decision-making process. Participation should make it possible for decisions on technology to be accepted by a larger spectrum of society despite divergent normative convictions. In the end, this will also improve the robustness of such decisions and enhance their legitimacy (Gibbons et al. 1994). Several approaches and methods have been developed and applied in the recent years, such as consensus conferences, citizens' juries, and focus groups (Joss and Belucci 2002).

TA for Shaping Technology

In the engineering sciences, the challenges with which TA is confronted have been discussed as demands on the profession of engineers. The value dimension of technology has been shown in many case studies, especially in engineering design processes (van Gorp 2005; van de Poel 2009). Decisions on technology design involve value judgments. In this respect there is, in other words, a close relationship between TA on the one side and professional engineering ethics and the ethics of technology on the other.

TA is one of a number of activities that provide orientation to and support for societal opinion forming and political decision making. Within the various approaches which can be subsumed under the social constructivist paradigm, the impact of those activities is primarily seen in the field of technology itself: ethical reflection aims to contribute to the technology paths, products, and systems to be developed (Yoshinaka et al. 2003). Theory-based approaches of *shaping technology* have been proposed, for example, by means of technology assessment (Rip et al. 1995) or variations of social construction of technology (Bijker and Law 1994). They have introduced strong claims for *influencing technology* by reflecting its social role and its consequences in the debate. The central message is that a "better" technology could be designed and constructed by using SST and CTA or other social constructivist approaches. The overall aim "to achieve better technology in a better society" (Schot and Rip 1997) shall be realized by looking at the very shape of technologies itself. The social construction of technology has even been extended to the social construction of the *consequences* of technology. In order to achieve a more environmentally and socially friendly technology, network-oriented approaches of the sociology of technology tried to control the problem of non-intended side effects of technology by applying adequate strategies of shaping technology during its genesis (Weyer et al. 1997).

TA Approaches Relevant for Design for Values

Within the branch of TA addressing the shaping and design of technology directly (see section "TA for Shaping Technology"), several approaches have been developed of which some of them also have been implemented in practical projects. In this section I will briefly introduce the constructive TA, the approach of the Association of German Engineers, the Leitbild assessment, and ideas going for socially more compatible technology.

Constructive Technology Assessment (CTA)

The basic assumption of CTA (which was developed in the Netherlands) is that TA meets with difficult problems of implementation and effectiveness whenever it concerns itself with the impacts of a technology after the latter has been developed or is even already in use (Rip et al. 1995). According to the control dilemma (Collingridge 1980), once the impacts are relatively well known, the chances of influencing them will significantly decrease because that knowledge will only be available in the later stages of development. It would therefore be more effective to accompany the process of the *development* of a technology constructively. The origin of technological impact is traced back to the development phase of a technology and the many decisions to be taken there so that dealing with the consequences of technology becomes a responsibility that already starts in the technology design phase. CTA argues for the early and broad participation of societal actors, including key economic players, users, and people affected in these early stages. In normative respect, CTA builds on a basis of deliberative democracy with a liberal picture of the state putting emphasis on self-organizing processes in the marketplace. Three processes have been proposed (Schot and Rip 1997, p. 257f.):

1. *Technology forcing*: Influencing technological progress through the promotion of research and technology as well as through regulation is how the state can intervene in technology (see section "TA for Policy Advice: The Case of Parliaments"). The influence of the state is, however, seen as restricted. CTA therefore also addresses other actors such as banks and insurance companies, standard bodies, and consumer organizations. Through their business and organizational policy, these institutions can directly intervene in certain technological innovations, for instance, by dispensing with chlorine chemistry, by investing in environmentally compatible manufacturing technology, or by developing social standards that are also valid for branches of a company located in developing nations.
2. *Strategic niche management*: Political promotion of technology and innovation should, according to CTA, be concerned with occupying "niches" in technology's repertory. In these niches publicly sponsored technology can – if protected by subsidies – be developed step by step, can make use of processes of learning, can gain acceptance, and finally can maintain its own in free competition unaided by public support (this part of CTA is related to the more policy-advising TA; see section "TA for Policy Advice: The Case of Parliaments").
3. *Societal dialogue on technology*: CTA regards it necessary to create the opportunities and structures for critical and open dialogue on technology. This dialogue must go beyond the limits of scientific discourse and expert workshops and, instead, include representatives from the economy and from the population. This postulate applies to technology forcing as well as to niche management.

CTA has been applied to a great variety and number of different technologies so that a huge body of experience exists (e.g., Rip et al. 1995; van Merkerk 2007).

Leitbild Assessment

In Germany, the concept of empirical technology genesis research developed in parallel with CTA (Dierkes et al. 1992; Weyer et al. 1997). As in CTA, the paramount objective is to analyze the processes of shaping technology and of the embodiment of technology by society instead of looking on its impacts. The shaping and diffusion of technology are traced back to social processes of communication, networking, and decision making. TA accordingly consists of research into the social processes which contribute to technological design, analyzing the "setscrews" for intervening in these processes and informing decision makers on these findings. There is, in this concept, almost no further mention of technological impact; it is presumed that the unintended side effects could be completely or largely avoided by improving the process of technology shaping, in particular by involving the envisaged users, people possibly affected, and citizens with their particular views, perspectives, concerns, and values (Weyer et al. 1997).

The concept of a *Leitbild assessment* (Dierkes et al. 1992) was one of the attempts to draw more practical conclusions from that research. The empirical result of social sciences research was that technology development often follows broader and non-technological ideals which were called Leitbild (leitmotif, "guiding visions," cp. Grin and Grunwald 2000). Leitbilder are often phrased in metaphors which are shared, implicitly or explicitly, by the relevant actors. Some famous examples from earlier times of technology development and planning are the "paperless office," the "warfare without bloodshed," and the "automobile city." The expectation is that through societal construction of the Leitbilder, technology could be indirectly influenced in order to prevent any negative effects and to provide positive results. In a sense, this approach is a direct predecessor of Design for Values because social Leitbilder obviously include values – shaping technology according to a Leitbild therefore implies shaping technology considering particular values. However, the approach did not work in practice (Grunwald 2000b) because it was not made operable to be usable in the concrete workplaces where technology design takes place.

The Concept of the Association of German Engineers

The Association of German Engineers (VDI, Verein Deutscher Ingenieure) considered challenges of technology to society from the 1960s. A lot of publications of VDI addressed issues such as technology and society, responsibility of engineers, and a code of conduct.

The most prominent outcome of these activities is the VDI guideline no. 3780 (VDI 1991, also available in English), which has become relatively widespread. It envisages a "Guide to Technology Assessment According to Individual and Social Ethical Aspects." For engineers and in industry, assessments are to a certain extent part of their daily work. Evaluations play a central role whenever, for instance, a line of technology is judged to be promising or to lead to a dead end; whenever the chances for future products are assessed; whenever a choice between competing materials is made; or whenever a new production method is introduced to a company. Though evaluation may be commonplace in daily engineering practice, what is essentially new in this guideline for societal technological evaluation is its scope, which also includes the societally relevant dimensions of impacts as well as technical and economic factors. Technological evaluation should be conducted in line with societally acknowledged values. Eight central values forming the VDI "Value Octagon" have been identified: functional reliability, economic efficiency, prosperity, safety, health, environmental quality, personality development, and social quality (VDI 1991). These values are thought to influence technical action and fall under the premise (VDI 1991, p. 7): "It should be the objective of all technical action . . . to secure and to improve human possibilities in life."

The values identified by VDI shall be involved in processes of technology development, in particular in technology design. They shall virtually be *built into* the technology. Engineers or scientists should, on the basis of their knowledge and abilities, point the development of technology in the "right" direction by observing these values and avoiding undesirable developments. If this exceeds their authority or competence, engineers should take part in the corresponding procedures of technology evaluation. This mode of operation is rather close to Value Sensitive Design (cp. the respective chapter ► "Value Sensitive Design: Applications, Adaptations, and Critiques" in this volume) and to Design for Values. However, VDI did not put much attention on how to make this approach work. Therefore, the approach is well integrated in education of engineers at many technical universities but did not have much impact on concrete development yet.

Shaping Technology Toward Social Compatibility

Specific concern was and still is given to declining acceptance of technology and increasing resistance, e.g., because of risk perception. Many studies on the acceptance of key technologies or technology in general have been conducted since the early 1980s. In some countries monitoring procedures have been established to observe any change of the level of acceptance in the population. The experience of technology conflicts since the 1970s around some key technologies like nuclear technology or the gene technology (which sometimes led to warlike scenarios in some countries) raised the question whether it would be possible to avoid such conflicts a priori. The idea behind this approach is that technology conflicts could be avoided by taking into account the presumed acceptance in technology development and design, i.e., by developing technology in accordance with the values, norms, and fears of people (von Alemann et al. (1992). A strict orientation of new technology to existing values and patterns of risk acceptance was expected to overcome acceptance problems. Within the proposed approaches to shape technology in this way to assume better social compatibility, the *stakeholders* of technology development (customers, citizens, political parties, authorities, social movements – all groups or persons affected by technology policy) shall be involved in the decision-making process. The degree of involvement ranges from real participation in the decision-making processes to measuring the rates of acceptance by polls. The assumption is that if the people concerned are involved in the decision-making process, the result should find acceptance among them: "Technologies developed through such strategies will be socially more viable and accepted, which will enhance the economic viability of new products and processes" (Rip et al. 1995, p. 5).

This approach, however, which was proposed in the 1990s faces several difficulties. Among these is the philosophical criticism of a naturalistic fallacy being involved, the conclusion from factual acceptance to moral acceptability. Shaping technology in coincidence with the factual values of the majority of people does not guarantee that ethical standards will be met. Factual acceptance does not replace the necessity of ethical scrutiny and justification of issues under consideration. Furthermore, orientating technology policy directly to the currently accepted values of the majority of people runs into difficulties because of the possible lack of stability of factual acceptance. Shaping technology in accordance with the values of people at a certain time does not prevent the situation that the so-designed technology might become a problem or might even be rejected years later because of change of factual values, lifestyles, and behavioral patterns (Grunwald 2000b).

Design for Values as a Specification of TA

There is no clear-cut definition of TA. In the contrary, TA usually is not *defined* but *explained* by pointing to the motivations and diagnoses behind, by addressing the expectations toward TA and by referring to its methodology and its institutional contexts (see the preceding sections of this chapter, also Grunwald 2009a). Following this story line a lot of manifestations of TA have been developed so far and are, partially, elements of current practice. These approaches are tailor-made for specific constellations such as parliamentary TA or citizen's participation.

In this broad understanding of TA, it is possible and seems to be adequate to consider Design for Value as a specific manifestation of TA. To be more specific, Design for Values can be considered as a specification of TA in its function of shaping technology mentioned above (section "TA for Shaping Technology"; see also section "TA Approaches Relevant for Design for Values"). It has in common with TA in general the rejection of any technology determinism and the idea that technology can be shaped, at least to a certain extent, according to social and ethical values as well as with regard to democratically determined objectives. The specific constellation of Design for Values may be characterized by (1) directly addressing the context of engineering and, in particular, engineering design (van de Poel 2009) and by (2) highlighting normative issues involved in the design of new technology.

Looking at the history and on the experiences of TA in general, the question might come up on what could be learned from TA which now has been operating for about four decades. Regarding the major motivation of Design for Values to contribute to the design of technology in a way that technology would be in a better accordance with social and ethical values, some observations seemingly lead to a portion of skepticism. Those approaches in TA that are most relevant to Design for Values have not (yet) been very successful (cf. sections "Leitbild Assessment" and "The Concept of the Association of German Engineers"). Shaping technology with regard to social and ethical values seems to be a hard mission being confronted with obstacles and pitfalls. The experience of TA shows that the success of approaches such as Design for Values depends on several circumstances and boundary conditions.

A reference to the debate on shaping nanotechnology by taking into account ethical values might help to learn from that experience. In that field, highly ambitious models of social construction and *constructability* of technology were applied from the very beginning of an ethical debate on (Grunwald 2012). In the early time of the debate, ethical deliberation was expected to contribute directly to the development of nanotechnologies in order to achieve "better" nanotechnologies in the sense of being in better accordance with ethical values and societal goals. The following distinction on understanding the meaning of "formation of nanotechnologies" was proposed in order to better understand the consequences of the ethical debate on nanotechnology (Grunwald and Hocke-Bergler 2010):

- *Strong understanding*: "contribution to the formation of nanotechnologies" means "influencing the development of nanotechnology" in the sense of *directly* influencing the R&D agenda of nanosciences and, therefore, the further course of research and technology itself as well as its outcomes in terms of products and systems.
- *Weak understanding*: "formation of nanotechnologies" means "formation of the societal context of nanotechnologies," where the "context" could be the public perception, the positions of stakeholders, the interventions of regulators, etc. – with possible impacts on the embedding of technology into society and with a more indirect influence on nanotechnology at the level of products and systems.

The main result of a review of the developments of the past decades was that there is only weak evidence for the "strong" understanding of ethical contributions to the formation of nanotechnology. Ethical deliberation did not directly affect the nanosciences, but complemented the view on what should urgently be done in other fields of research (like nanotoxicology) or by motivating public debate and also contributed to nanotech as a public phenomenon. The main finding of Grunwald (2012, Chap. 10) is support for the weaker sense but rejection of the stronger one of "shaping nanotechnology by ethical reflection."

It would, however, be too early to draw the conclusion that Design for Values would not work because it apparently did not work in this particular field. The reason is the well-known control dilemma (Collingridge 1980). Nanotechnology at the beginning of the twenty-first century was in a much too early stage to be subject to Design for Values in a direct sense. Other cases show that taking ethical and social values into account in more concrete design processes can be an important element of the overall design of technology with positive results at the side of products and systems (e.g., van Gorp 2005). Thus, it turns out that it is crucial to identify appropriate occasions in the research and innovation processes to influence the further design process by reflecting in values involved. These occasions will, following the nanotech example, presumably not be located in the very early stages of new and emerging sciences and technologies (NEST) but might be found in later stages where more concrete applications are addressed.

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