Task 3.3 “Practitioners’ meetings”

Workshop 1 “Selecting the theme”

September 19th – 21st, 2012, Lisbon, Portugal

Information material

Dear participant,

The documentation here enclosed should help you prepare for the 1st Practitioner meeting. Here you can find a series of documents that deal with the workshop subject “Selecting the theme”:

1) A text selection from the EU project *Technology Assessment in Europe; Between Method and Impact - TAMI* (2004). Three chapters have been selected (highlighted in yellow in this pdf). There is also a section on TA-impact included, which is not the subject of this workshop, but we think it is useful to keep in mind the scope of a TA activity already at this stage.

2) A text selection from the incoming PACITA deliverable 2.1 *Institutional descriptions and case studies*. In this text the processes of theme selection for eight TA institutions are briefly described.

3) One more useful reference that covers also the workshop content:

> Grunwald, A., *Technology assessment - Concepts and methods*. In: Meijers, A. (Hrsg.): Philosophy of technology and engineering sciences. Amsterdam, Boston, Heidelberg, London, New York: Elsevier 2009, S. 1103-1146

These documents are placed in order of importance with respect to the workshop theme, so please consider the opportunity to read at least the first one.

The organizers

Final Report (12 month)
Restricted

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Project coordinator:
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Center of Technology Assessment in Baden-Württemberg (CTA), Germany
Danish Board of Technology (DBT), Denmark
Office of Technology Assessment at the German Parliament (TAB), Germany
Centre of Science, Technology, Society Studies at the Institute of Philosophy, Academy of Sciences of the Czech Republic (STS Centre), Czech Republic
Warsaw School of Economics - Institute of Modern Civilisation (SHG), Poland
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a) Results Method Group

Introduction

TAMI reflects on the activities of Technology Assessment institutions and their effectiveness. The central question therefore seems to be: which methods should TA use in order to optimise impact? This question sounds quite easy. Nevertheless this paper shows that reflecting on the impact of TA methods is a very complex endeavour. The goal of optimising impact of TA activities requires a comprehensive reflection on TA processes, TA quality criteria and, the institutionalisation and mission of TA. This paper strives to provide a common ground for such a broad reflection.
Section 1 provides a general definition of Technology Assessment. Based on this definition, a common framework to reflect on the relationship between method and impact is developed in section 2. Elements in this framework to consider are for example the institutional setting and the various phases of a TA project: situation appreciation, goal setting, project design, and project implementation. The following sections deal with those various elements. Section 3 distinguishes between various institutional settings in which TA projects are being designed and implemented. The institutional setting is discussed first because it influences choices made in every step of the TA process. Sections 4 to 7 describe the four phases that were introduced above. Section 4 discusses various dimensions or aspects that need to be considered when appreciating a situation. Attention is given to the issue dimension, the political dimension, social dimension, innovation dimension and the availability of knowledge. Section 5 described various possible categories of goals. Section 6 deals with the project design phase. A method toolbox consisting of three classes of TA methods – scientific, interactive, and communication methods – is introduced. In line with these three classes of methods three types of quality criteria are treated: scientific, interactive and communication quality criteria. These criteria refer to different sets of requirements that TA has to cope with, that are, TA has to comply with scientific and democratic demands and needs to have an impact on the political and societal debate. Section 7 deals with the project implementation phase. Finally, in section 8 an overview of the findings is given and some conclusions are drawn with respect to the relationship between methods and impacts.

1. TA Definition

Obviously, the way by which TA methods have to be or could be mapped depends on the preceding understanding of TA. Even the scope of the notion "TA method" depends on the underlying TA definition. The basic TA definition is decisive concerning both of the aspects: which methods have to be taken into account, and in which way they could or should be classified.
TA is a generic term for non uniform, partly even contradictory approaches and activities and therefore the definition problem occurs (Grunwald 2002). It is not obvious and self understandable what the "common" should be, if one views technology forecasts, risk communication, problems of legitimisation, innovation funding etc. One of the main conflicts in the discussions on TA is based on the fact that everybody wants to have his/her own question concerning future technologies in the centre of the definition of TA. However, by doing this they usually pressure other aspects to the brink or even out of the TA-definition. This, of course, meets with stiff opposition from other TA-actors.

It is not very helpful to go on with the discussion on that level. A definition of TA could be based on many different categories and if there is no consensus about these categories than not only the definition is not consensual but moreover there is no chance for a rational dealing with this problem. Possible definitions are:

- Definition via the tasks and functions of TA. Focussing on the contribution of TA to the social problem solving.
- Definition via certain special aims, e.g. early warning against technically induced risks (in the beginning of TA) or currently the stressing of innovation funding.
- Definition via the methods used. The kind of methods (e.g. scientific or participatory) used in TA are taken as defining categories
- Definition via the subject-matter. What is investigated concretely by TA and on which aspects of technology is it related to?
- Definition via the addressees. Which persons, groups or social subsystems should be addressed and advised by TA?

It becomes obvious very soon that definitions on the basis of these criteria on the one hand side will overlap but on the other hand will lead to diverged assignments. If one wants to have a common definition at all, and a common project on TA is a good reason to go for such a definition, because one has to identify what should be considered and what should not to be taken into consideration, than a not too narrow definition according to this end is necessary. However, one should not forget that this definition has to be scrutinized in the context of the TAMI-project. The main criterion can be formulated in a means-end situation: Is the definition adequate for the purposes of TAMI?

The following proposal is based on the first mentioned category focussing on TA's contribution to the social problem solving:

> *Technology assessment (TA) is a scientific, interactive and communicative process which aims to contribute to the formation of public and political opinion on societal aspects of science and technology.*

This definition contains two substantial distinctions. Firstly, TA is dealing with contributions to the public and political opinion forming and not with the decision making itself. TA offers knowledge, orientation or "approaches" to overcome social problems (e.g. unintended consequences, loss of confidence, problems concerning legitimisation). TA is neither able nor legitimated to solve these problems. This is part of society by means of their institutions and decisions processes. There is a difference between advising and shaping: TA is not shaping of technology but providing the knowledge for and advising to shaping of technology.

Secondly, science, interaction and communication are of crucial importance and form the three pillars of TA. *Science* provides knowledge about consequences of technology, conditions of implementation and mechanisms of controlling the technology development ("scientific methods"). The social relation to technology is characterized by problems of legitimisation, conflicts and loss of confidence. This is where TA offers and organises *interaction* between the opponents, the stakeholders etc. in order to overcome these problems. Examples for these "interactive methods" are risk assessment, mediation and participation of citizens. *Communication* is relevant for the distinction "public" or "political" opinion forming. "Successful" communication in these fields has to meet different requirements, obviously. Therefore, communication is moreover directly connected to "stay in touch" with the

social surrounding. "Communicative methods" like newsletters, interactive websites, science theatres etc. are used to realize that.
The attribute "societal" refers to aspects of technology which are relevant for society. This includes for instance ethical, economic, environmental, social aspects of technology.
The attribute "technology related" refers to the question of which notion of technology is relevant in TA. Probably all attempts to develop a comprehensive notion of technology have to combine the substantial (artefact/tool) and the procedural (technical procedures) aspects of "technology". Often TA refers only and directly to artefacts/hardware and deals with the "more detailed analysis of the place of 'things' in chains of action" (Handlungsketten) (Wagner-Döbler 1989, p 25; in the same sense Ropohl 1979/1999). Relevant questions concerning this aspect are (a) how do human beings get the artefacts, (b) how do human beings behave relative to a artefact, (c) how do human beings get rid of the artefacts. Technical procedures and software are also part of the technical "world". Surgical operation techniques, programming and techniques of knowledge management can also be in the focus of TA. This procedural aspect of technology should not be disregarded. Objects of TA are in this sense of technology:

- ways of acting, in which technology is developed or produced
- ways of acting, in which technology is used
- ways of acting, in which technology is removed from the context of use (recycling, disposal)

The attribute "science related" takes into account that already scientific findings can lead to TA-relevant questions. The difference between scientific application oriented research and the early stages of a new technology/procedure are fuzzy (this is also the reason why "science and technology" is often used as fixed, inseparable expression). Therefore e.g. TA-projects focussing on the "early warning" aspect are science related. Scientific research can also be on the agenda of TA, when they reach a certain order of magnitude. Huge high energy particle colliders, fusion laboratories are examples for that.

2. From Method to Impact: A Complex Relationship

TAMI, as a network of reflection on the relation between method and impact not only needs a common definition on Technology Assessment, but it should be able to base its discussions on a common framework. Having such a framework is a necessary step in order to work with common notions and to understand the relationships between method and impacts.
As a first general feature, one has to acknowledge that the relationship between method and impact is of very complex nature. Of course, TA practitioners must choose the right methods to get some impact. But, how to choose the right methods? What are the criteria to be used? And are things so simple that one has only to pick up the right methodology? Things are much more complex.
Figure 1 tries to systematize the relevant variables intervening in the relationship between method and impact. According to this scheme, the possible impacts of TA activities depend on many variables, related to the TA institution itself, to the situation (or context), to the goals or objectives of the TA-project, to the selected method(s) and to the project management.

4. Situation Appreciation

Technology Assessment addresses many different issues linked to technological advances and is thus confronted to a variety of questions to work on, with their own characteristics. TA might address questions related to nuclear energy, stem cells, privacy in the information age, waste management or sustainable development, just to cite some examples. Moreover, the same issue can lead to a quite different questioning in different contexts. The way to tackle the issue might depend, for example, on the technological development, on the political context or on the general mandate of the TA institution. In this respect, a sound appreciation of the situation is an important step towards achieving any impact. The right appreciation of an issue and its context will help a TA institution to fix realistic and appropriate goals for a given project, and then use the appropriate methods in order to set up a TA approach able to realise these goals. It might be useless to launch a consensus conference on new technological developments without having, for example, previously considered what the technology can achieve (e.g. can xenotransplantation diminish the lack of available organs?) and their implication on law (is it authorized, do we need a revision of the existing laws, etc.?). On the contrary, a scientific study on a long discussed technology might bring fewer added values than a participatory project. It is thus important to get tools in order to better apprehend the kind of situation a TA project is addressing, in order to implement the right method with the right goals and get the more impacts out of it.

Practically, the situation appreciation is part of the pre-phase of a TA project. Usually a kind of discourse analysis is used in order to draw a "map" of the ongoing debate. Who are the relevant actors and which arguments do they use? Which positions do they take against each other? Moreover a media analysis to investigate positions in the debate and the public resonance to a specific topic can support such a discourse analysis as well as expert interviews and expert or stakeholder surveys, which shall help clarifying arguments and positions. The analysis of relevant documents complements the situation appreciation. The situation appreciation is of crucial importance for the following TA-project, because improper assessments will lead to projects contributing to solutions to irrelevant problems. However, due to practical reasons a balance between "quick" and "detailed" has to be realised. Moreover a monitoring of the situation is relevant during the whole project in order to keep track with changes in the environment.

Examples: The Situation Appreciation in Practice

Drawing a Map of the Existing Debate on GMO's

In May 2002, the viWTA started with a project to give new impulses to the existing debate on GMO's in agriculture and food. Before making the methodological choices, a situation appreciation study was conducted. The situation appreciation study had four main goals:

- to list all relevant actors that are connected with the debate on GMO's in Flanders (social map). The authors of the study came up with more then one hundred organisations;
- to give an overview of the positions of the different actors. This work was based on a discourse analysis of websites, press releases, magazines, interviews,…
- to analyse the ongoing debate on GMO's in Flanders. Which arguments do the different stakeholders use, what do they think of each other. This part of the study showed very clearly that several stakeholders had a completely wrong idea of the positions of other stakeholders and especially of the position and opinion of the public.
- to map all existing and coming legislation on regional, national and European level that has to do with GMO's

The conclusions of the study lead to the decision of organising a consensus conference and a stakeholders' forum in the course of the project. The consensus conference would aim for a clear and subtle view on the opinion of the public. The stakeholders' forum (to be held at the end of the project) was meant to create an opportunity for stakeholders to exchange and discuss views and positions. The study made it also possible to inform and involve all the relevant stakeholders. In this way, it became possible to build up a broad societal support for the project.(Goorden et al. 2003)

Situation Appreciation of the Polarised Discussion on Cloning
In the autumn of 1997, the Dutch Minister of Public Health, Well-being and Sports asked the Rathenau Institute to contribute to the societal debate on cloning. The reasons were the public reactions to the birth of the cloned sheep, Dolly. Since the weight of the political debate was height and the public discussion so polarised the Rathenau Institute decided that an open and transparent process was needed to appreciate the situation and accordingly determine the project activities. To do this, the Rathenau Institute organised a hearing in the old conference room of the Lower House on March 26, 1998. At the hearing a panel of (former) Members of Parliament questioned researchers, representatives of biotechnology companies and interest groups, and ethicists about the state of the art of the technology, the possibilities of application, the arguments for and against certain applications of cloning and the reasoning behind these arguments. The hearing clarified three relevant issues for debate: cloning of stem cells, cloning of animals for the production of medicine, and animal cloning in animal husbandry. On these topics expert meetings, open to the public, were organised. Also two meetings were held to obtain more insight into the way various religious and political traditions deal with the ethical problems surrounding cloning. To further the public's input to the cloning debate a lay panel was set up. The panel could take part in all of the other activities organised by the Rathenau Institute and was also given the time and money to develop its own activities (e.g. questioning experts, visiting firms, etc.). (Biesboer et al. 1999)

In the following, an attempt is made to systematise the dimensions to consider when appreciating a situation. In this paragraph we treat the (1) issue dimension, (2) political dimension, (3) social dimension, (4) innovation dimension, and (5) the availability of knowledge. This systemisation should be understood as a checklist and a rough guide of what should be taken into account. In order to point out the relevance of the situation appreciation for the following steps "goal setting" and "project design" many references concerning and anticipating these steps are already made in this paragraph.

4.1. Issue Dimension
The first - and trivial - dimension is the issue a TA project addresses. Looking at the working programmes of TA institutions, we can see that the issues addressed are variegated: the themes are manifold and framed in different ways. In this context, when appreciating the situation, it might be important to be aware of the way the issue is framed. The following typology tries to systematise the different kinds of issues TA projects are addressing:

- *Technology oriented issue*
  This is the traditional – and maybe the more widespread – way of doing TA. The consequences of a technology already existing or just being developed or of a techno-logical trend are interdisciplinary analysed or put under discussion among experts and/or laypeople. Many technology-oriented projects address questions related to new developments in biotechnologies/biomedicine and in information and communication technologies. Other important issues are new materials, transportation systems, waste-treating technologies and energy supply techniques.

- *Domain oriented issue*
  Technology intervenes in many domains of our life, like health, work, entertainment, mobility, etc. In this respect, the Technology Assessment community is also interested in evaluating or discussing how a certain domain of human activity is affected by new technologies. Classical examples of such projects are e-commerce or e-health. But more focussed projects can also be taken into consideration, such as road pricing or call centres.

- *Consequence oriented issue*
  The topic of interest might rely on certain consequences of technologies. In this context, the project will not mainly address the technology, but will put the

emphasis on societal trends or changes that are technology related. Typical examples are projects addressing the questions of privacy, sustainable development, gender division, North/South relationship, etc.

In all these different types of issues the situation appreciation includes investigating the relation between the specific TA issue and the specific context the TA project has to face. This usually will allow identifying the TA relevant aspects of issue and context in more detail. This fact, however, makes obvious that an individual TA-project touches all the above mentioned dimensions. A project that is domain oriented must, of course, consider the technologies involved and look at the consequences. A technology-oriented project must consider the domains that are affected by the technology under scrutiny and the consequences it may have. Finally a consequence oriented project must be aware of the different domains concerned by the problem and the technologies involved.
Nevertheless this typology is helpful in order to identify where the project starts from and what its initial perspective is. This influences the goal setting of the TA-project and the project design.

4.2. Political Dimension
Issues addressed by Technology Assessment are generally politically relevant. This relevance, however, might change depending on the stage of the policy-making process we are in, and the kind of political debate which is going on. In this section we distinguish between three phases: agenda setting, policy making and implementation phase. Finally, we discuss the situation in which the political debate and policy-making process is blocked.

- *Agenda setting phase*
  In this phase government has not yet officially addressed the issue. Still, an issue may be virulent among expert, citizens or interest groups. These may be aware of or sensitive to certain potential risks related to a new technology – for example environmental or health risks of new materials ("whistle-blower-effect"). On the contrary, some experts could have visions from unexpected utilities or chances of innovative technology. Anyway, in such cases there will be a high degree of ignorance and low awareness in general.
  In this type of situation the goal of a TA project might be to assemble the knowledge available and to identify the areas of ignorance in order to be better capable of assessing the risk under consideration. In the case of proving the suspicion true the "early warning" function of TA applies. The aim is to put the issue on the political agenda or to raise awareness in the political system concerning the issue under consideration. In other cases TA might lead to an early recognition of chances of new technologies.

- *Policy making phase*
  In this phase an issue is already on the political agenda, and at the stage where fundamental decisions have to be taken. In this case, a TA project might help to structure the debate, to make plural and comprehensive information available, to highlight and to assess the alternatives and the actions to be taken, to make the decision-making criteria transparent et cetera, in order to fulfil its task of supporting decision-making.

- *Policy implementation phase*
  In this stage of the policy cycle, there is a clear policy on the issue at stake (e.g. fostering e-learning), but the policy has still to be implemented. In this respect, TA might offer inputs on the ways to implement given policies related to technology in order to contribute to an efficient way of "domestication" or "embedding" the respective technology into society.

- *Political deadlock*
  Sometimes a debate on a certain issue is in a political deadlock; no solution is in sight. For example: the European debate on genetically modified food or the debates on nuclear waste disposal sites in many countries. Here, the role of TA in contributing to the management of conflict might be to contribute to overcome the blockade by communicative measures and by systematic analyses of possible alternatives which could open new ways of thinking and new paths to overcome the deadlock-situation.

Interestingly, the phase and character of the policy debate might change in the course of the TA-project, especially for long and complex projects. As a matter of fact, when a project lasts several months – or even a couple of years – the chance that the political situation evolves has to be taken into consideration and be integrated in the project design. In specific cases there might be a need for integrating special monitoring tasks into the project in order to prevent overlooking such changes or noticing them too late. This calls for an ongoing situation appreciation process. On the basis of this, the initial project design may be modified. Because political changes can happen suddenly, the project design needs some flexibility in order to react to such unexpected events (see section 6.3.3).

4.3. Social Dimension
Another characteristic of a TA issue is the social dimension of the issue under consideration. We start the discussion of the social dimension with some general remarks about the role of values in TA. Next and related to that we will treat the following (to a certain extent overlapping) issues: public awareness, possible technology conflicts, and roles of various relevant actors and their relationships.

- *Value dimension*
  The value dimension is inherent to every technology as has been shown by TA in the last decades. However, there are differences in how deep ranging the relevance of values in a concrete case and situation is. The probability of the emergence of conflicts depends (among other factors) on this relevance of values. For example, technologies affecting deeply anchored values concerning the beginning and the end of human life, are often highly controversial in a pluralistic society. Other technologies, which might be considered under more economic issues (like the substitution of classical materials by new ones), perhaps complemented by ecological aspects, can be judged in a more neutral way though showing also normative aspects. One of the tasks of a situation appreciation is, therefore, also to identify the relevant (perhaps hidden) values involved and their capability to leading to technology conflicts.
  A possible goal of the TA-project is then the investigation of the TA issue with respect to the specific "framing" which has been chosen, and the search for alternative framing. The aim should be to make the particular values transparent

which are underlying the specific framing of an issue in order to make an open and transparent debate possible and to avoid biases in the TA resulting from the framing of the issue to be dealt with.

- *Relation to the public*
  An adequate situation appreciation process should address the way the public is aware or perceives a certain issue. Questions to be considered here are:
  - Does the issue already raise interest within the public? Are there reports or discussions in the mass media (newspapers, TV, internet)? Which role do the mass media play?
  - How is the interest expressed if existing? Is there fascination, rejection, mistrust against experts or against the political system, fear against the future, need for open debate, etc.? Are the chances or the risks of science and technology in the foreground?
  - Who is leading the social discussion? Are large organisations (parties, churches, social movements) aware of the issue? Is there sufficient (whatever this means in detail) willingness among stakeholders and people affected to participate in a public debate?

- *Possible technology conflicts*
  With respect to the social dimension of a TA issue it is important to identify potential conflicts surrounding technology at an early stage. A situation appreciation in this respect should include the aspects of societal acceptance, power and communication. Relevant questions, therefore, are:
  - Is there evidence for social acceptance problems of certain technologies? Could the debate even run into a blockade situation? How serious are positions of rejections to be taken?
  - Has the debate so far been compatible to the requirements of social fairness or is there evidence for a severely unbalanced distribution of power in the public communication? Is the legitimisation of certain positions or even of democratic institutions in dealing with the respective technology been questioned?

- *Social roles and relationships*
  The design of a TA study may decisively depend of the assessment of the roles of experts, decision-makers and laypersons and their mutual relations in the respective field. Has there been evidence for mistrust against experts and decision-makers? Does the expert dilemma (a situation in which experts are confronted with counter experts, science becomes politicised and the values behind science become explicit) apply? If these questions are answered with “yes” this will have an impact on how to conceptualise the TA project, for example concerning the use of participatory instruments.

In all these fields, the way an issue is discussed in the public might evolve during time. A scandal, a new scientific finding might deeply affect the social debate and, thus, the TA project on the issue. This shows the importance of keeping in track with developments in society and to be open for adaptation or reaction.

4.4. Innovation Dimension

Analogue to the metaphor of the policy cycle, TA may play different roles in different stages of the innovation cycle. Some TA projects are rather prospective, in a sense that they explore technologies in the development stage, possible social practices that these technologies would imply and societal goals that are not yet discussed (take, for example, the TAB study on nuclear fusion research).

In other cases, TA projects will address questions related to existing technologies. Here, TA may focus on the shaping of technology. For example, do we want the Internet to be better controlled or let as a free space? A TA may also consider the practical implications of the widespread use of a new technology how to actualise this technology to the present situation. For example, what about the multiplication of In Vitro Fertilisation in industrial countries?

Along the development path of a specific technology, TA has different entry points. TA relevant questions are different in the various phases of the innovation cycle, as well as there are different stakeholders and social groups to be involved. Accordingly, fitting TA questions to the development phase of the respective technology and to the corresponding decision-making requirements is an essential element of a situation appreciation. Following the widely used model of the innovation chain, and adding the notion of an embedded technological system, we could identify the following different functions of TA.

- *Research and development in early stages*
  TA at the early R&D phase takes the function of a "science assessment". In the foreground are chances and risks of the developments, topics of public promotion of research and possible regulation needs.

- *Industrial research*
  Research for new products or processes under the rules of competition at the marketplace is much closer to having a direct impact on society. In this phase those impacts and consequences of technology and ways of dealing with them are the main subject of TA.

- *Marketplace*
  Sometimes, when products enter the marketplace the public discussion really starts off. A prominent recent example of this is the introduction of GMOs on the European market in the mid-1990s, which led to fierce political debate and eventually a temporary moratorium of GMOs in Europe. TA has responded to this situation with public participatory events to clarify what 'the public' actually thinks about the issue and why.

- *Widespread diffusion*
  Some technologies rapidly enter the market and have a high diffusion rate. For example the rapid market introduction of mobile phones. This led to public discussion about health effects of mobile phones and its related infrastructure. TA task is to acknowledge, discuss and clarify these voices or warnings and give them a proper place within the political debate. In many cases, for example asbestos and PCBs, early and even 'loud and late' warnings were ignored by decision-makers (Harremoës et al. 2001).

- *Embedded technological systems*
  Sometimes the limits of success of technological systems that are already deeply embedded in society are coming into view. An example of this is livestock farming in the Netherlands. The goal is to move towards a more sustainable and animal friendly system. In such a case, established institutes are often too closely related to existing interests and are not able to break up existing practices and look for new ways. In the event of a looming crisis, TA may help to look for new ideas in order to innovate the system.

4.5 Availability of Knowledge
TA has to provide knowledge and perform knowledge management. Knowledge generation in TA shows specific difficulties because anticipatory and therefore hypothetical knowledge is required. The design of a TA study depends on the amount and quality of knowledge already available in the respective situation and on identified knowledge deficits and gaps. Therefore, an exploration of the availability of knowledge is belonging to each TA pre-phase. Different points of departure in this field are:

- high-quality knowledge available, high degree of consensus among experts and scientists;
- high-quality knowledge available only in some relevant fields concerning the issue under consideration, with other areas of ignorance or high uncertainty;
- there is knowledge available about gaps of knowledge ("gewusstes Nichtwissen" "acknowledged Ignorance"), for example due to some suspicions about technology risks without undoubted empirical evidence (like is the case of Electro-Magnetic Fields);

Obviously, the portion of TA related to knowledge generation and knowledge management – compared to the portion of discourse and communication – will be different in these different types of situations – which then will have a large impact on the design of the respective TA project.

5. Defining the Goals of a TA-Project
After the appreciating of the general situation, the goals of a concrete TA-project have to be defined. It is also possible that a TA institution decides to stop the process here, because it considers that the situation does not correspond to the kind of situation it can contribute to (compare the paragraph on "institutional setting"). If it decides to continue on, then many different kinds of goals might be possible. We can, however, systematize the kinds of goals around the following goal categories (clusters)[1]:

- *Scientific assessment*
  This is typically seen as the condition sine qua non of technology assessment. Different technical options have to be identified and assessed in comparison. This needs the gaining of knowledge about these technical options. Moreover knowledge about the societal, political, ethical consequences of these alternatives must be developed and presented in a comprehensive way.

[1] These goals of TA-project can be compared or are mainly identical with the "roles" of TA identified from the impact analysis perspective.

4. Typology of Impacts

This approach has been clarified by working out a typology which is made up of three dimensions of impacts which can be related to three dimensions of the issues that TA is dealing with.

One could roughly discern three dimensions of impact that TA or policy consulting in general can be expected to have: impact in the sense of **raising knowledge** on issues among policy makers or in public debate, impact in the sense of **forming opinions/attitudes** of actors involved in policy making and the debate, and impact in the sense of **initialising actions** taken by policy makers or other actors.

These dimensions of impact can be linked to three dimensions of the issue that TA-projects usually deal with and TA is expected to generate knowledge about. TA has to deliver (as comprehensively and unbiased as possible) information on the **technological and scientific aspects** of the issue that is at stake (e.g. features of technology, results/or problems of scientific risk assessment, economic costs, eco-balances, etc.). A description of the problem or issue at stake would be incomprehensible without describing the **societal aspects**: TA has to deliver knowledge about relevant actors (their interests, values etc.) and possible social conflicts that can evolve around the technology under consideration. On the grounds of a proper description of the scientific and technological aspects and in connection with a description of the social environment (debate, actors), TA has to analyse the **policy aspects** of the problem; i.e. has to consider the restrictions and opportunities of policy making and has to develop policy options, such as exploring politically viable ways for problem solving (legislation, R&D funding, action plans). At the end, it has to again evaluate policy options with regard to possible side-effects (e.g. social conflicts) they might produce.

Generally it is possible to translate the term "impact" (of TA, of policy consulting) by "application of knowledge/information". The above given three dimensions then might be read as an application-continuum leading from "raising knowledge" to "forming attitudes/opinions" and to "initialising action/initiative". In the first dimension one could speak of a low level of application in the sense of "client taking notice of results of a TA process", which on the side of the user may imply a "fuller understanding of the problem" or "a broader view of aspects related to the problem" without directly (or visibly) inducing a change in attitude or behaviour. This is the necessary first step to a more explicit application in the dimension of "attitude" and "action": the application of (new) knowledge stemming from TA studies becomes visible (in the agenda and in policies) and knowledge is observably applied as arguments in the debate, and this in a further step might have visible impacts on decision making in the sense of changing the path of policy making and bringing up new political initiatives. The latter two steps obviously imply not only awareness but *application* of knowledge in a narrower sense and therefore presume an active adoption of knowledge by the user - it has to be integrated into the "belief system" of actors as "conceptual knowledge" (see above). The application of knowledge for guiding political action is apart from its adaptability to the knowledge and interest structure of actors highly dependent on constraints and opportunities given by the actual policy situation (e.g. need for compromises in policy networks, respect for existing policy coalitions, compatibility with existing policy programmes etc.).

It is therefore appropriate to differentiate the three dimensions in terms of level of impact: With regard to the influence of TA on the policy making process it is more likely (and can be regarded as a relatively minor effect on policy making) to make actors aware of possible unintended consequences of technology, perspectives of actors and policy options ("raising knowledge"), than to induce a change in the agenda or political initiatives (e.g. new legislation). The three dimensions of the typology should not however be read as a continuum in time, i.e. that first a TA project is carried out, then the results are delivered to the client and the public where they may induce a learning process which again may lead to new initiatives in policy making or to decisions that close the debate. Impacts in all three dimensions may result throughout the entire TA process. Already at the beginning of a TA process, discussions between TA-practitioners, the client, stakeholders and experts about appropriate problem definition, questions and problems that should be scrutinized, may induce a learning process and result in a change of attitudes or opinions of relevant actors. Since a TA-Process usually implies communication between the TA-institute and the client throughout the whole process and (in particular when communicative methods like workshops, participatory procedures are part of the process) a change in attitude and opinions and even effects on ongoing decision making may be induced in any phase of a TA-project.

Table: Typology of Impacts

IMPACT DIMENSION ISSUE DIMENSION	I. RAISING KNOWLEDGE	II. FORMING ATTITUDES / OPINIONS	III. INITIALISING ACTIONS
TECHNOLOGICAL /SCIENTIFIC ASPECTS	SCIENTIFIC ASSESSMENT a) Technical options assessed and made visible b) Comprehensive overview on consequences given	AGENDA SETTING f) Setting the agenda in the political debate g) Stimulating public debate h) Introducing visions or scenarios	REFRAMING OF DEBATE o) New action plan or initiative to further scrutinise the problem decided p) New orientation in policies established
SOCIETAL ASPECTS	SOCIAL MAPPING c) Structure of conflicts made transparent	MEDIATION i) Self-reflecting among actors j) Blockade running k) Bridge building	NEW DECISION MAKING PROCESSES q) New ways of governance introduced r) Initiative to intensify public debate taken
POLICY ASPECTS	POLICY ANALYSIS d) Policy objectives explored e) Existing policies assessed	RE-STRUCTURING THE POLICY DEBATE l) Comprehensiveness in policies increased m) Policies evaluated through debate n) Democratic legitimisation perceived	DECISION TAKEN s) Policy alternatives filtered t) Innovations implemented u) New legislation is passed

Using these dimensions of impact and issue we derive a matrix that shows nine types of impacts of Technology Assessment. An inventory of 21 roles or functions of TA in policy making that was developed by members of the TAMI-project on the basis of their experience as TA-practitioners as well as by referring to existing case studies on the political role of TA procedures (cf. Buetschi/Nentwich 2002) can be described according to these types of impact.

4.1. Raising Knowledge

"Raising knowledge" can be seen as the "classic" mission of TA as a particular branch of policy consulting. The establishment of TA in the 1960's and its development in the following decades was to a great extend encouraged by policy makers perceiving a lack of access to reliable scientific information on modern technologies that were growing in importance for almost every field of policy making (National Academy of Sciences 1969, Hetman 1973, Vig & Paschen 2000). The perceived deficit referred to knowledge on hard scientific facts (on features of technology), the socioeconomic context relevant to the implementation of technology, social needs and interests often causing conflicts in implementation, as well as on viable and socially accepted policy options to shape or steer technology development.
The three types of impact in the column "raising knowledge" are directly related to the content of a TA process and to the "deliverables" of TA. The outcome of a TA-process (e.g. a report) as well as the process itself (participatory procedures, workshops etc) make policy makers or other relevant actors aware of new aspects of the problem/issue at stake such as scientific knowledge on paths of technology development, risks, chances, unintended consequences etc. (**scientific assessment**), interests or perspectives of actors involved (**social mapping**) and problems and options of policy making (**policy analysis**).
Providing knowledge on scientific, social as well as policy aspects of technology in the sense of "making the client more aware" is closely associated with the quality of TA as a scientific process but nevertheless not restricted to a particular type (i.e. classical scientific policy consulting type) or method of TA. The quality of the knowledge provided may depend on scientific standards of the TA process as well as on the level and quality of inclusion of stakeholders and societal groups in it. Quality of the output - no matter if this may be a written (scientific) report or the results of workshop - is a prerequisite for "raising knowledge". It is however not a warrant: whether the results of a TA process are taken into consideration or not, depends to a large extend on factors such as visibility, timeliness of the process as well as on contextual factors which are out of the reach of a TA institution (see below, section on influencing factors).

4.1.1 Scientific Assessment

Scientific assessment comprises two classic roles of TA that are related to its function of making scientific knowledge as comprehensive as possible available for decision makers.

Technical options assessed and made visible (a)

With regard to the rapid development of science and technology and the overall dependence of social welfare on the application of R&D, there is a need for policy makers to be informed about what is about to come and to compare different possible paths of technology development. To make technical options visible and to assess the viability of different technological paths by means of foresight studies or scenario writing, is a prerequisite for rational decision making in innovation policies.

PACITA - Deliverable 2.1

Description of Parliamentary TA institutes in Europe

Switzerland – TA-SWISS

Priority setting

The TA-SWISS office selects TA-interesting topics and proposes them to the Steering Committee, even though the latter can also do it. As Adrian Rüegsegger explains, the team "looks for interesting themes through monitoring literature, newsletters, websites, newspapers, meeting with people, monitoring what other TA institutions are doing". A new technology, or even an established one that has a new spin, is interesting if it's expected to have some significant impact on the Swiss society, in particular on economy, societal habits, environment, health, legislation, etc.

Once a staff member finds a topic that could deserve more attention, he/she explains the topic to the whole staff during a meeting or even in a less informal discussion. If the theme is considered interesting "we write down a short proposal (two pages) on the subject, that we bring for approval to the Steering Committee", adds Rüegsegger. If the Committee approves, the person in charge can dig into the subject, making a detailed paper on it (10-15 pages). At this stage the project manager usually decides, after consulting the office, to discuss the topic within a small group of experts, with the aim of finding the important issues and better define the subject matter limits. The final paper describing the state of the art of a new technology is brought to the SC for final approval, which then leads to a call for tenders. After the call is closed, the offers received by the TA-SWISS office undergo a three stage selection: the office makes a first internal selection based on general criteria (the offer has to comply with given guidelines, it has to fulfil the call's requests, it has to be well written and organised, etc.); then the office contacts a group of experts in the call's field and asks for their evaluation; finally a short list of selected offers (usually 3 or 4) is proposed to the Steering Committee for a final decision. The budget for a study is about 140 thousand SFr. (€115 thousand), and a study usually lasts one year and a half. The whole procedure, from topic finding to offer selection, is regulated by internal guidelines.

The way to participatory methods projects is more straightforward. Since there's no need for a call, the office can start immediately working on the subject, once it has been approved by the SC.

Overview of projects and output

In the last three years TA-SWISS dealt with the following projects.

Studies (interdisciplinary scientific analyses)

- *Nanomaterials: Effects on Environment and Health* (foreseen conclusion 2013)
- *Opportunities and risks of electromobility in Switzerland* (foreseen conclusion 2012)
- *Robotics and autonomous devices in health care* (foreseen conclusion 2012)
- *Localisation Technologies* (2012)
- *Human Enhancement* (2011)
- *Biomass fuels – second generation* (2010)
- *Indicator-based decision-making systems* (2010)
- *Nanofood* (2009)
- *Anti-aging medicine – myths and chances* (2008)

Participatory projects (consultations aimed at gathering the views of citizens)

- *PubliTalk «Digital Natives»* (2011)
- *Dialogue «The Internet and me»* (2010)
- *World Wide Views on Global Warming* (2009)
- *publifocus eHealth and the electronic patient file* (2008)

Other projects (international projects or workshops):

- *Experts' Workshop on Cloud Computing* (2011)

- *EPTA Project on Genetically modified plants and foods* (2009)

Research and fact finding

All the interdisciplinary studies aim at finding facts and having a balanced assessment of chances and risks of new technologies. Research is organized through external contracting by means of open calls for tenders. The communication of a call is made through the network of TA-SWISS contacts: newsletters, direct mailing of known researchers, publication of the call in the TA-SWISS website and in the websites of befriended institutions (e.g.: the Academies).

Case study: Anti-Ageing Medicine: Myths and Chances

Selection of the topic

For several reasons, this topic has been considered as suited for a TA-Project. (i) The «ageing of society» is a well known phenomena, at least in Europe. Modern medicine makes it possible that, e.g. in many European countries, life expectancy for women is more than 80 years and for men it is between 75 and 80 years – and it is still rising. But what about quality of life? (ii) Anti-Ageing medicine promises a good quality of life for old people, if you use certain treatments or products. But are these things effective? (iii) Biological research finds more and more relations between genetic factors and ageing. In animal experiments, life expectancy of worms, flies and mice could be extended by genetic manipulation. Are such things on the horizon for human beings?

Considering these interesting developments, the TA-SWISS staff proposed to the Steering Committee to carry out a study on anti-aging medicine. The Steering Committee accepted and the staff elaborated a detailed description of the topic and a plan for the project. Furthermore, other institutions have been asked for co-funding. Two institutions joined the project funding body, i.e. the Swiss Academy of Medical Sciences (SAMS) and the Swiss Innovation Promotion Agency (CTI). Finally, the Steering Committee accepted the focus, plan and budget of the project and the call for tenders for the study on anti-ageing medicine could be launched.

Germany – TAB

Organisation of work at TAB

Proposals for TA-studies can come from one or several of the parliamentary groups in the Committee for Education, Research and Technology Assessment as well as any of the other committees in the German Bundestag. During its two decades of existence TAB has managed to become a unit supporting a broad range of parliamentary committees. Actually the fact that TAB reports are initiated by and are subject of consultations of many parliamentary Committees is regarded as being a success factor of the model in the 2010 evaluation report of the parliament (Bundestag 2010, 19).

New subjects do not come out of the blue, however. Parliamentarians are addressed by others and asked to take the initiative for a new TAB project on a particular subject of interest, as is clearly stated in the NGO interview. As for the setting up of new projects the reception in the parliament can also be influenced by the resonance that TAB reports find outside parliament, such as civil society organisations asking parliamentarians for their opinion on a TAB report. The NGOs and other societal actors might thus function as *"multiplicators"* for TAB even with respect to the parliament.

Under the guidance of the chair of the steering committee for TA, the TA-rapporteurs and the director of TAB discuss the political and factual relevance of requested topics. TAB submits a statement for every proposal on its scientific workability as well as considerations of the objectives, substance, and methods. Topics are then selected and unanimously presented to the committee for debate and decision. A proposal is accepted when a third of the committee members do not oppose it. This procedure ensures the political relevance of reports and its connection to the needs of parliamentary committees (Bundestag 2010, 15). The number of requests for TAB studies submitted by parliamentary groups and committees has grown continuously. In the first quarter of 2010 alone, 67 requests from almost all committees were sent to the steering committee for TA. TAB, due to restricted resources, had to combine several of the proposals in a reasonable way to at least cover a greater part of the demand. In the latest report of the parliamentary evaluation report of TAB this fact gave reason to stress that the budget of TAB has not been increased over the years and obviously is not sufficient to fully answer the increasing demand for TAB studies (Bundestag 2010, 16).

In the interview with members of the TAB staff the process of narrowing down the broad array of proposed subjects to a manageable set of projects is described as follows. All 64 proposals for projects - a heterogeneous set of issues and questions - were discussed intensively in the scientific unit: "*Are they relevant and scientifically feasible? Are they "too futuristic"? Has TAB sufficient expertise in this field to work with external experts on equal terms? Some of the proposed topics are emotionally charged in Germany and have been discussed for decades without any concrete result. Such topics are always delicate to assess. Sometimes topics are already covered by other German/European research projects, and then these questions are postponed until these projects provide results".* In the actual case TAB finally proposed a list of 13 topics, in which more than 30 questions of the MPs had been integrated. These topics were discussed jointly by TAB and the committee with the aim of coming to conclusions on a priority list. The whole procedure took around 3-4 months. However, 50% of the questions could not be covered and integrated in the working program for reason of restricted personal and budgetary capacities.

After decision by the Committee, TAB is responsible for the scientific and organisational implementation of the TA studies. The project team begins with intensive research and consultations with experts on relevant research issues and findings. These also help in to identify opposing scientific opinions and controversial positions of various interest groups. For central issues defined for a study, TAB makes recommendations to the Committee on expertise to be commissioned from external experts or scientific institutions. Cooperation with such external experts and their reports is a central element of project work.

Over the entire term of the project, the team monitors and analyses the ongoing scientific debates and related public and political discussions. Particularly when interim findings are available, workshops and expert meetings are organised to bring together scientific experts and Members of Parliament. Representatives of societal groups are frequently included. This also aims to promote communication between science, society and German Parliament and the transfer of knowledge and opinions, even before the completion of a project. The results of all activities are summarised by TAB, and the project is concluded with a final report.

Topics

TA projects and monitoring activities are central working areas for TAB. These areas have proved ideal, particularly as a means of channelling the numerous requests for topics received from the expert committees and parliamentary political parties into analytical processes suitable for the purposes of German Parliament.

> TA projects deal with complex issues of science and technology. Such projects apply a comprehensive, interdisciplinary approach and a long-term perspective (e.g. new materials, fuel cell technology, nanotechnology or e-commerce).

> Monitoring activities consider selected aspects of developments in science, technology and society (e.g. regulation, innovation, experience gained in other countries). Their thematic focus makes them particularly suitable for current issues. They are also helpful in identifying and determining the exact content of future and more comprehensive assessments. Finally, they contribute to strengthening the core competences of TAB in important areas (e.g. themes such as genetic diagnostics and gene therapy, energy supply, renewable raw materials, acceptance of new technologies).

These analytical approaches – for which the cooperation partner Fraunhofer-Institute for Systems and Innovation Research (ISI) is principally responsible – are used to open up specific additional prospects:

> Future reports are intended to identify technological fields with relatively medium and long-term relevance which are expected to require parliamentary action. Among other things, this improves the Committee's opportunities to put issues on the political agenda at an early stage.

> Policy benchmarking uses internationally comparative studies of policy approaches in other countries and political options for action being debated there, to contribute to the Committee's ability to assess solutions in various countries and areas of technology.

> Innovation reports are intended to review current innovations in areas characterised by particularly rapid development, a high degree of sensitivity and a low level of empirical information.

The topics on which TAB conducts assessments cover a broad range of current scientific and technological issues with high relevance for politics. One focus is on the field of environment and health, examples are reports on environmental technologies and economics, medical technologies and ecological and health aspects of mobile telecommunication and transmitter stations. Another focus is on the dynamic and controversial issue of bio and gene technology. In this area, TAB has submitted reports on such topics as biotechnology and developing countries, status and prospects of genetic diagnostics and cloning of animals. Examples for subjects of projects in the field of resources and energy are fuel cell technology, nuclear fusion and geothermal energy.

Selected recent and ongoing projects
> Hazards and vulnerability in modern societies – the case of a large-scale outage in the electricity supply
> Pharmacological and technical interventions for improving performance: perspectives of a more widespread use in medicine and daily life (»enhancement«)
> Renewable energy sources to secure the base load in electricity supply – contribution, perspectives, investments
> International competitiveness of the European economy with regard to the EU state aid policy: the case of nanoelectronics
> Clinical research in Germany with special focus on non-commercial studies
> Regulations for access to the information society
> Future potentials and strategies of traditional industries in Germany – impacts on competitiveness and employment
> How can research contribute to solving the problem of world food supply?

Case Study: Hazards and vulnerability in modern societies – using the example of a large-scale outage in the electricity supply

The case study in this section is meant to exemplify the more general description of TAB's working methods given in the previous chapters - from selecting topics and scoping to the dissemination of findings. The project on large scale outage of electricity supply was selected because it has recently been completed and it includes the organisation of a public event in the parliament – the latter being a relatively new element of TAB's work.
In 2008 the Office of Technology Assessment at the German Bundestag (TAB) was commissioned by the Committee on Education, Research, and Technology Assessment to analyse the consequences of a prolonged and widespread power outage. The study was to explore the possibilities and the limitations of the national system of disaster management to cope with such a large-scale emergency. The commissioning of the study was motivated by the notion that electrically powered equipment has almost completely penetrated the living and working environment, and that thus the consequences of a prolonged and widespread power outage would amount to a particularly serious hazardous situation. A power outage was thought to affect each component of society's critical infrastructure, so that it would be nearly impossible to prevent a collapse of all of society. A particularly critical aspect was that social awareness of these risks was still in its infancy despite the potential impact of these dangers and disasters.

Initialisation and commissioning of the study

The project was initiated by a group of parliamentarians from the German parliament's standing Committee of Internal Affairs. Actually it was a group of four parliamentarians each representing one of the parliamentary groups. The initializing group of MPs had been actively engaged in discussions with the so called *Forschungsforum Katastrophenschutz* (Research Forum Civil Protection), a platform for continuous exchange on civil protection organised by a group of experts from science and administration. Point of departure of asking for a TAB study was the *Grünbuch Katastrophenschutz* (Greenbook on Civil Protection) that was initiated by the Committee of Internal Affairs. This report discusses several disaster scenarios and the disaster management schemes, infrastructures and means to deal with these by public authorities. A deficit or requirement identified in this document as well as by the discussion on civil protection in Germany in general was that no reflection of the catastrophic effects of a complete outage in the electricity supply was available. The MPs involved had an interest in filling this gap and in putting the issue of a large scale electricity outage on the agenda of governmental bodies and civil protection and disaster management authorities. The Committee of Internal Affairs unanimously decided to ask the steering committee for TA, the Committee for

Research, Education and TA, to set up a TA study on the subject. In June 2008 the Committee for Research, Education and TA officially authorized the Office of Technology Assessment at the German Parliament (TAB) to design a study on the effects of a large scale electricity outage in Germany.

Setting up of a pre-study
Following a first scanning of available documents, consultation with experts and a discussion with the initiating group of MPs from the Committee of Internal Affairs, the TAB, suggested starting the TA process with a pre-study. This horizon scanning effort was felt to be necessary due to the complex division of tasks between the federal and state governments, the broad range of public authorities (federal, state, county, municipalities) that had to be taken into account and the broad range of infrastructures (80% of them owned by private companies) that had to be considered (electricity, telecommunication, water supply …). Moreover, the availability of data (in particular from private companies) had to be clarified. The pre-study was also to help clarify the scope of the project and to select from the landscape of areas of social and economic that most probably would be affected by an outage those areas that should be in the focus of the project. To that end apart from desktop research and contacts with experts and stakeholders organised by the TAB project team in Berlin, an overview study was commissioned to the private research company PROGNOS. This study provided a first sketch of the wide range of areas that would be affected by an outage and provided a first overview on possible impacts, critical infrastructures and existing disaster management plans via expert interviews. The project work also benefitted from an ongoing study on the effects of an electricity outage commissioned by the state government of Baden Württemberg. TAB was easily able to establish contacts with the responsible researchers since this study was led by a group of experts from the Karlsruhe Institute of Technology (KIT) – the home of the Institute of Technology Assessment and Systems Analysis which is running TAB on behalf of the parliament.

During the pre-phase, the TAB project team (five researchers with backgrounds in political science, sociology, engineering and physics) consulted and established contacts with a large set of institutions relevant for the issue: Experts from the *Bundesamt für Bevölkerungsschutz und Katastrophenhilfe,* BBK (Public Authority for Civil Protection and disaster relief), the *Bundesamt für Sicherheit in der Informatonstechnik,* BSI (Federal Office for Information Security) , *Gruppe Zivile und Militärische Zusammenarbeit* (Joint group of reservists from the German armed forces and civil protection organisations, such as the Red Cross and others), the Ministry of Internal Affairs, as well as relevant private actors such as water supply companies, energy supply companies and German Telecom. Close cooperation with BSI helped to access information on disaster management in the field of telecommunication, which was not supplied by the German Telecom company. In this and in other cases access to detailed information about disaster management provisions was denied due to company secrecy. In order to avoid any suspicion on the part of security and disaster management authorities that the aim of the TAB project was a kind of clandestine evaluation of their performance, establishing good contacts with these organisations was regarded as being of primary importance. The set of explorative and horizon scanning activities and consultations helped to get an impression of what the most relevant issues were, and confirmed that so far no pertinent study (apart from the at that time ongoing study in BW mentioned above) was available.

Catalonia (Spain) – CAPCIT

Priority Setting
CAPCIT itself is responsible for discussing and making decisions on its own work plan and on the issues about which it is necessary to prepare technology assessment (TA) reports. So members – both parliamentary members and the members from scientific and technical institutions – jointly decide what issues should be focused on and which of these need to be addressed in a report. Up to this point on average there has been no more than two meetings in any year. The members of the institutions are also involved from the outset on giving advice on the suitability of devoting time and resources to specific topics. But in deciding its work plan, CAPCIT may also take requests from: (1) The Board of the Parliament of Catalonia; and (2) The Committees of the Parliament of Catalonia. Once CAPCIT decides that it is necessary to address a particular topic or the issue has been put forward to the body by one of the above bodies, a decision needs to be made as to whether the report will be produced and if necessary who shall be responsible for producing it. The various alternatives are that: (1) One of the scientific and technical institutions represented in CAPCIT is designated to

produce the report; or (2) Production of the report should be commissioned to a different scientific and technical institution and proceedings will be initiated to appoint this institution.

TA Approaches

The method used at the moment by CAPCIT is the approach of expert-based analysis to evaluate the consequences of scientific and technological advances and thus to provide the most neutral support to decision makers. CAPCIT delegates all responsibility for the production of the reports, including the choice of assessment method, to the institution charged with undertaking the research.
Up to this point, neither the opinions of the general public nor those of different stakeholders (other than those of scientists) have been considered. However, in 2010 CAPCIT supported a citizen forum called *Young Catalans Science Parliament*, which was organised locally by FICSR and funded by the EU, in which four controversial and modern topics about Life Sciences were discussed by teenagers between the ages of sixteen and eighteen. The Catalan parliamentarians were handed out the resolutions adopted during the forum.

Overview of Projects and Output

Since its inception, CAPCIT has worked on the following areas:
a) *Genetically modified organisms* (GMOs or transgenic). A popular legislative initiative was presented in the Parliament which sought to ban genetically modified crops. CAPCIT decided to call for three separate reports on the topic from various scientific institutions represented on CAPCIT. These reports were presented in the plenary session of the Parliament before discussions took place on the issue.

b) *Human papillomaviruses*. Proposals had been submitted in the Parliament to restrict vaccinations for this virus and more information was sought on the issue before making a decision. Two reports were made – one to document the different actions undertaken in other European countries and the other centred on scientific aspects.

c) *Nanotechnology*. Again three reports were made – one to document the information available from other TA European offices, another to document social perceptions, and the third to deal with scientific aspects.

Case study: GMOs

Catalan Popular Legislative Initiatives (PLI) constitute a procedure of direct involvement by citizens in bringing about regulations by presenting at least 50,000 signatures. In July 2008 a PLI was presented in the Parliament, which sought: a) To ban genetically modified crops in the territory of Catalonia; b) To guarantee the adequate labelling of produce; and c) To promote the research of the GMOs possible effects. The transgenic issue is highly controversial in Spain because it is the first producer of GMOs in Europe, and Catalonia is the second largest region in Spain in terms of land mass covered by GMOs. Many ecologist associations, farmers, and citizens are sensitive towards the possible consequences that the introduction of GMOs could have on public health and on the environment. The promoters of the PLI, an ecologist platform called *Som lo que sembrem* (We are what we grow) were supported by more than a hundred thousand signatures of independent citizens.

The signature collection procedure for a PLI is done using traditional sheets. The time-frame for collecting signatures is 120 days once the PLI has been accepted, with the possibility of a 60 days-extension if considered justified by the Parliament Board. Guaranteeing the signature collection procedure is the responsibility of the municipal secretaries, Electoral Census Offices and also the Catalonian Statistics Institute. In order to validate a signature, an essential requirement is that the signatory be older than sixteen years of age and be registered on the Electoral Census, and this must be demonstrated by means of certification. This certification confirms the capacity of the signatory and avoids multiple signatures by a single citizen.

<u>Flanders (Berlgium) – IST</u>

Priority setting

The role of viWTA/IST in S&T-related debates is double and has different temporalities. On the one hand, the institute has a proactive role to pick up weak signals of what is going on in society, with regard to S&T (notably through trend studies), where S&T provide input and trigger discussions. On the other hand, it has to be responsive to current parliamentary discussions and interests and to be able to provide useful, timely, neutral, scientific information, advice and recommendations. In the end it has been mainly through the second aspect that viWTA/IST had to prove its usefulness to its first and most important target groups: the MPs and the parliamentary committees.

Since the viWTA/IST evaluation, the annual working program is based on a trend study that makes an inventory of technological state of the art developments and foresights. It is based on own monitoring activities but also fed with the input from trend databases (e.g. ZPunkt) and interviews with trend watchers, marketers, futurologists and foresight experts. This trend analysis is periodically updated. In a next phase, colleagues in the first place (e.g. from the EPTA network) review that trend study. After that, several stakeholders are invited to give their opinion and to indicate where they see priorities and focus for TA work in Flanders. Then the relevant Parliamentary committees are consulted (innovation, education, environment, welfare). Those committees generally tend to broaden the scope and ask for more concrete studies, adapted to their needs and expectations. In the last phase, all that input comes together in the final working program. That working program consists of a series of projects and related communication plans and is submitted to the board for approval, every year in December.

The Chairman of the viWTA/IST Board is involved in two types of activities: first, the set-up and approval of the yearly working program after it has been discussed within the board of directors. Secondly, given the increase of demands coming from Parliamentary committees and ad hoc committees, along with the Director, he tries to integrate the suggestions, recommendations, and reports from the Institute in the debates that take place inside the Parliament or in its committees. The public relations and ad hoc tasks take a lot of resources and the latter affect the nature of the classical TA work. Even though such tasks favour the contact with MPs and are quite successful, quantitatively, they also drag away time and energy from its core TA mission, because they overemphasize the short-term parliamentary service function of viWTA/IST.

The institute sometimes struggles to make its way to the current debates, which reveals a deeper gap in temporality between the short-term political discussions in Parliament and the long-term projects and prospective trend watches the institute undertakes.

The insider and outsider interviewees generally see viWTA/IST as an advisory body, which bases its recommendations on scientific research, including participation of the general public. That means that the participation can either contribute to gathering the data needed for assessing technologies, but can also be a goal in itself, when the aim of the project is to draw attention and raise awareness to some topics (like for technology festivals). As it gives insights in the topics at stake, the institute triggers and organizes debates and can sometimes even contribute to some change in the public opinion (cf. the more balanced debate that took place on the societal effects of gaming after a viWTA/IST study had been conducted in 2008). In the end, it is still the link to the parliamentary work that prevails. Every year, around 8 to 10 projects are carried out. However some of them cover more than a year.

Research and fact finding

The institute is not very involved in an academic publication strategy. However, viWTA/IST has actively been involved in editing or co-authoring books or book chapters, most of the time being based on its participation in European projects. For example: Slocum N., *Participatory Methods Toolkit*, United Nations University, Comparative Regional Integration Studies, 2003; Decker M. and Ladikas M., *Bridges between Science, Society and Policy*, Verlag Berlin Heidelberg, Springer, 2004.

Domains in which viWTA/IST has undertaken TA studies include (but are not limited to):

- Information and communication technologies (gaming, digital divide, …)
- Health issues related to society and technology (fertility technologies, ageing society)
- Energy technologies and climate change
- Life sciences (biotechnologies, synthetic biology, brain sciences and cognitive technologies, …)
- Converging technologies (NBIC – nano, bio, info, cogno)

Case study: Digital inclusion project

The digital society program of viWTA/IST looks at the impact of Information and Communication Technologies (ICT) on society and has resulted in projects such as ICT & elderly (2004), ICT & poor people (2006), ICT & privacy (2006), Game on (2007) and Intelligent transport systems (2009). In 2009 and 2010, this program focused on the impact of the digital divide (and digital inclusion, i.e. the whole of measures to remediate digital exclusion mechanisms causing a digital divide) in the Flemish society. It thereto organized two activities: a TA study on the digital divide in Flanders and a three day technology festival on digital Flanders. These two activities and are further labelled as the digital inclusion project. Both were highly interconnected: viWTA/IST released the results of the TA study during the technology festival and digital exclusion was a leitmotif during this technology festival. The results of the digital inclusion project were released in November 2010, during the Belgian presidency of the European Union and the European Year against Poverty and Social Exclusion.

Hence, this case study constitutes of two components that are linked together: the TA study, with focus on the policy support function of viWTA/IST's mission, and the technology festival, with focus on the public dialogue function of viWTA/IST's mission. In this section we make a short life cycle analysis of both components and focus on the links with politics.

Political relevance of the digital inlcusion project

The digitization of our society is no longer an emerging trend but a daily reality: health, mobility, home, office, public services, media, culture, entertainment,… are domains that are impacted by digital applications and services. Their omnipresence has had a significant societal impact over the last years and their impact is expected to increase over the coming years. Information is created, shared and consumed at an ever-increasing speed. The positive societal effects of digital society generally refer to the 'anyplace anywhere, anytime' availability of information and communication possibilities for a higher quality of life. The negative societal effects emphasize that this 'anyplace anywhere, anytime' availability does not apply to everybody (e.g. digital divide / digital exclusion), does not improve everybody's life (e.g. digital harassment / cyber bullying) and may cause derailed societal behaviour (e.g. violent game behaviour in real life / social media addiction).

Over the years, several political initiatives in Flanders have been launched to govern our digitizing society. In 2005, it was decided in the Flemish Parliament to set up an *ad hoc* committee 'Digital Flanders'. With a set of parliamentary hearings, this committee aimed at delivering a policy note on the strengths, weaknesses, opportunities and threats concerning digital developments in Flanders. In July 2008, this committee delivered its societal policy note and the Flemish Parliament suggested to the Flemish government to take appropriate steps in the domains of e-mobility, e-culture, e-health/e-care and e-government.

On the one hand, the increasing importance of digital applications and services require people to develop and maintain appropriate (digital) skills. Motivation, user experience, education and a social network are hereto crucial. People, who do not possess the necessary skills, risk to be excluded partially or fully in our contemporary society. On the other hand, an organized reflection on the impact of our digitizing society with a broad input from politicians, companies, civil society organizations and the general public did not take place in Flanders so far. In 2008, viWTA/IST expressed therefore the dual need to further explore the societal issue of digital exclusion and to bring politicians, civil society organizations, digital media experts and citizens together to contemplate on our digitizing society and to discuss tangible issues.

<u>The Netherlands – RI</u>

Priority setting: continuous realignment

The two year work program is the most important driver for the daily work. In the program for 2011 and 2012, nine themes covering relevant scientific and technologic developments have been defined. The themes range from *Autonomy in healthcare* to *The value of science,* from *Urban society* to *Excellent science.75* In practice, we see that every new work program has strong linkages with the previous one, but that priorities and focus evolve over time.
How does the work program come about? The process that leads to a work program is bottom-up and top-down at the same time. In 2010, a program council was established by the board of the Rathenau Institute.

This council meets several times per year and discusses new developments and the institute's research program. When a new program has to be written, all staffers are requested to give input, leading to a first draft that is being discussed internally. Management and coordinators start prioritizing and clustering. In the next phase, a draft version is discussed with the Institute's board, who is formally responsible for establishing the program. The board has the formal task of consulting relevant institutions and organizations, at least the Royal Academy of Sciences (KNAW) and the Scientific Advisory Council on Government Policy (WRR). Also the minister of Science is to be consulted, who ultimately sends the work program to the lower and upper house, accompanied by his or her opinion.

More tacitly, there is a continuous internal process of scanning the horizon for relevant themes. Coordinators and management have an important function as 'trend catchers'. Upcoming sociotechnical trends, like the information society, the green economy and the convergence of nanotechnology, biotechnology, information technology and cognitive science (NBIC) are spotted in an early phase and judged on their relevance for parliamentary TA. In addition to this, senior and junior researchers spot for trends in their own fields of expertise. This is facilitated by a daily overview of relevant articles in newspapers and magazines, provided by one of the communication officers. This continuous scanning of the horizon by (almost) the complete institute, feeds the ongoing projects, but also builds up knowledge for the next work program.

In practice, there is a lot of effort involved in translating the broad themes from the program into clearly defined project plans. In fact, the selection process of relevant topics starts anew, be it on a project level instead of a thematic level. Project leaders are responsible for writing a project plan. After thorough discussions with coordinators, management and communication department, this is sent to the Institute's board for approval. Not only the project budget and planning, but also the scope of the project has to be approved of. Often implicitly, three criteria are applied in this process of clarifying and fine-tuning a project plan. It should contain a technical and/or scientific component. Furthermore, there should be political, societal and/or moral relevance. Last, but not least, there should be a need for a "twist" in the societal or political debate: deepening, broadening and/or intensifying it.

The work program is the dominant driver for the projects that are carried out, but in daily work there is room to deviate from the program. One of the internal factors is that there is not always sufficient organizational capacity to take up all topics from the program within the two years ahead. This is also due to the fact that some of the 'old' projects still need completion within the timeframe of the new program. Furthermore, it is a deliberate management choice to maintain some flexibility, in order to deal with unforeseen external demands. Especially when a political need becomes apparent, the Rathenau Institute should have same 'spare capacity' left to mobilize expertise from previous projects. Examples of such ad-hoc events that build on earlier projects are the organized expert meetings on vaccination and animal testing.

Not only projects compete for priority, but also tasks within a project. It is hardly ever the case that the project plan is 'simply' carried out. Project leaders continuously re-align the activities in their projects to developments in the outside world, in discussion with coordinators, communication department and management. It is a deliberate management choice to allow for this maneuvering space within the practicalities of a projects, instead of taking a project plan as a blueprint that only needs checking on milestones and budget. The rationale is that the chances of impact increase, when such externalities are accounted for in the project.

Types of projects and output

The types of projects, carried out at the Rathenau Institute, is diverse. This is partly due to the additional Science System Assessment task, next to the more classical task of Technology Assessment. Another reason is that the Institute is formally entitled to approach a broad range of domains, ranging from health care, ICT, chemistry and biology to climate and sustainability. The task description of the Institute is domain independent, unlike institutions as the Health Council or the Energy research Centre of the Netherlands (ECN). Or, as the 1999 evaluation committee explicitly stated, which is still relevant: *"The Rathenau Institute is entitled to broaden its working are to all those areas for which special advisory bodies have been established. The Institute has to be able to take up these issues from the perspective of Technology Assessment."*

The following table gives an overview of the TA projects that were carried out from 2008 – 2010, classified along the lines of the 2009 – 2010 work program. The other table lists the projects for SciSA.

For 2011/2012, both departments have committed themselves to carrying out one integrated work program.

The Usable Body Medical Devices Personalization of Care Technology Dilemmas in Embryo Research Market for Human Tissue Human Enhancement Vaccination Global Human Health 2 SYBHEL: Synthetic Biology for Human Health: Ethical and Legal Issues Making Perfect Life Brain Sciences	**Hunger for Resources** Bio-based economy Energy in 2030 Nanotechnology NBIC[78] Management of Natural Resources World Wide Views on Global Warming Animal Welfare Ethics in Agriculture Green Chemistry Geo-Engineering Synthetic Biology Plant Biotechnology
The Prevention Society The Screening Society Databases in the Picture Electronic Patient Dossier Privacy Migration: Technological Borders of Europe	**Digital Hyperconnectivity** Public Space 2.0 ITC Delta (conference) Social Robots The Rules of the Virtual Reality
TA Networks and Methods EPTA Conference 2008 CIPAST: Citizen Participation in Science and Technology Technology Assessment Autumn School 2008 PACITA: Parliaments and Civil Society in Technology Assessment GEST: Global Ethics in Science and Technology	**Public and Corporate Activities** Saturday Night Science (Technology Festival) Spinoza Debates (Science Cafes) Public Perceptions of Science and Technology 25th Anniversary of the Rathenau Institute Flux Magazine

Overview of TA projects at the Rathenau Institute for 2008 – 2010.

The Value of Science Evaluating Research in Context (ERiC) SIAMPI: Social Impact Assessment Methods by studying Productive Interactions Overview of Research Evaluation: Practices and Discussions Knowledge Transfer in (Bio) Science Parks Open Access	**The Dynamics of Science** Regenerative Medicine Transdisciplinary Educational Science Political Science E-social Science Taxonomy Indicators for the Dynamics of Research Fields Transdisciplinary Didactics and Neuro Sciences

Valorisation	Development of Water Research Cooperation Patterns in the Water Sector Imaging Neuro and Cognitive Science
Institutions Biosecurity Legislations and its Effects on Research Practices Changing Responsibilities in New Science and Technology Allocation of Research Funding Large Programs: Knowledge for Climate International Research Programs EURECIA: Impact ERC on national research systems Selection of Projects as Decision-Making	**Organization of the Science System** International Comparison of the Organization of Science Systems Investing in Large-scale Research Infrastructures Social Structure of Knowlegde Networks Biosecurity Regulation and Research Practice Governance and Organization in Six Countries Focus and Mass
Research and Research Groups Career Development for Researchers Roles in Science Management, Organization and Performance of Research Groups Life Cycle of Research Groups Management and Performances of Research Groups Impact of the National Science System on Career and Research	**Methods, Data and Information about Science** Modelling Knowledge Dynamics Bibliometric Software Tools Data and Indicators Workgroup Facts and Figures Portal for Science Science Indicators (Summer School) Knowledge Maps (Exhibition)

Overview of SciSA projects at the Rathenau Institute for 2008 – 2010.

Case study: Global Trade in Human Biological Material

The foregoing sections have made clear that over the years, the Rathenau Institute has developed a broad portfolio of projects, in terms of topics, methods and stakeholders. From this variety of projects, we have chosen the Global Trade in Human Biological Material as a case study. The reason is that it is a clear example of aiming for media attention, as a leverage for getting political impact. This approach is considered an important one at the Institute. From an international perspective, it is also rather unique, compared to the ways how TA institutions in Europe work.

The case study analyses the way in which the Rathenau Institute in the Netherlands has gained awareness among publics and members of parliament about emerging markets for human biological material and the need to discuss its potential effects and implications. The main outputs of this project are a book and a TV documentary. This analysis focuses on the political process of framing and agenda setting. More information about the content of the project can be found online via www.rathenau.nl/en.

In short, the project describes how the human body has become a commodity. Tissues, cells and organs have gained financial and exchange value. Products are being developed with blood, bone or foreskin as main ingredient. Organs, ova and sperm are for sale online. And wombs are rented out by surrogates. Commercial organisations make a profit out of human body parts, donors are willing to sell and recipients are willing to buy. As such, a global market has arisen for human biological material. This probes issues around donation and consent, about international law and moral, about solidarity and welfare, and about the way in which we perceive our bodies and build our identities.

Research background, design and strategy
The project on emerging markets for human biological material was essentially a follow-up to a 2009 study on the use of human tissue. The highly politicised nature of this topic, ignited by the announcement of a new law on human tissue and informed consent, provided the starting point for further research into ways of (re) using human tissue. This 2009 study dealt with the storage and residual use of human tissues and cells for other purposes than individual treatment of the patient, so called secondary use (for scientific research, transplantation, production). The main outcome of this project - which included a public survey (N=1038), clinical intervention study in a Dutch cancer hospital and socio-legal analysis of governance frameworks for human tissue – was that publics and patients in the Netherlands are not aware of the fact that their tissue is being stored and potentially re-used. With high levels of trust in medical practice and science, this is unproblematic as long as commercial use of the tissue is being excluded without prior and active informed consent. For several years, a Dutch human tissue act has been announced. The Dutch secretary of Health explicitly mentioned the need for informed consent for commercial re-use. An important issue, though, was the lack of a clear (legal) definition of this commercial re-use. Because of both the sensitivity of the subject and political engagement, further research was needed to feed the public and political debate.

So the topic was put on the research agenda of the Rathenau Institute both because of political momentum and anticipated policy development and regulation (external factors) and because of existing research experience and a well-functioning project team wanting to further immerse into the subject matter (internal factors).

This was the starting position for the current project, for which a research proposal was written and discussed by members of the management team and board. Also a committee was installed of high-level stakeholders in the field in order to respond appropriately to potential external critique on either subject or outcome of the research, and to keep close contact with different constituencies in the field, which eased, for example, access to interviewees and data. The committee oversaw the process and most members were involved in the research as well (for example as interviewees).

The research itself kicked off early 2010 with a broad horizon scan of potential ways and practices of commercial use of human tissue, cells and organs. Along the documentary and internet research, the focus narrowed down to specific cases that would represent the diversity of markets in which parts of the human body were commodified. This led to the following breakdown in terms of research focus:
1) Classical donation markets: blood and organs (specifically: kidneys)
2) Emerging reproductive markets: egg donation and one-stop-baby-shops (including surrogacy, sperm trade and fertility treatments)
3) Recycle markets: biotech products based on human foreskin and bone.

<u>Norway – NBT</u>

Organization of work at NBT
All work is organized around projects. The Board decides independently which projects are adapted, and Board members are represented in all project groups. In the end phase, the projects are presented to the relevant standing parliamentary committee, often in combination with an open meeting at the Parliament.

Projects to be executed are selected in a flexible manner: there are so-called core projects that are part of a biannual work-plan, but Board has complete liberty to decide on new projects at any meeting. Projects of the core portfolio are selected in a balanced way. Every second year, the Norwegian Board of Technology decides on a core portfolio of projects for the next period. By making a biannual work program it is possible to cover different technologies and policy areas (such as Climate change and low carbon technologies; eHealth and welfare; Internet policy and privacy; Emerging technologies), as well as different TA methods.

The selection procedure for the project sis based on multiple filtering. In the search for new projects, the Board invites research institutes, business and industry, private persons, public administration and politicians to brainstorm, as well as an open invitation to the public, in order to obtain proposals for topics and projects for the Board's agenda. This ensures that the Boards agenda stays transparent and open, and gives thematic inputs from many different areas of society. In addition, the Secretariat makes analysis of societal developments, technology trends and provides an overview of what is going on in international TA, and on this basis also proposes project ideas.

After the idea gathering, the secretariat makes a list with short descriptions of 50-100 project ideas. The Board then selects approximately 20 projects for a closer scrutiny. All ideas in this smaller group are then evaluated by the secretariat, using criteria such as societal importance, technological component, political interest and added societal value. In this phase, the Board also consults MPs and policy makers to get relevant information and feedback, but not on a formalized level.
The Board makes a final decision on the project portfolio at a workshop for the Board near the end of every second year. Typically, 8-12 projects are selected for implementation.

However, the Board has the freedom and flexibility to move fast and decide on new projects at any meeting. The work plan always includes some spare capacity to be able to do spin-off projects, to follow up when the parliamentary committees give a clear sign they need input, or to respond to technological developments or events that were not foreseen.

The Board members are represented in all project groups. They are active members of the expert groups like any other member. They report back to the Board together with the secretariat. Concerning the final documents to be submitted to Parliament/Government the Board approves of the quality of the report and the scope. In projects with expert groups the formulation of recommendations and conclusions is delegated from the Board to the expert group.

In the end phase, the projects are presented to the relevant standing parliamentary committee, often in combination with an open meeting at the Parliament. Usually, the recommendations are handed over at an open meeting or a seminar. In most cases there is a panel discussion with parliamentarians from different political parties. The NBT produce a special publication to the Parliament called "Fra RådettilTinget" ("from the Board to the Parliament"), a 4 page publication similar to a POST-note and the Danish document "frarådettiltinget". The document is a summary of the recommendations from the project. In some projects this is the final publication, and in others there is a longer report as well. The recommendations are usually sent to both Parliament and Government at the same time, but first presented for the Parliament.

The main channels of communication are the papers presented to Parliament and to the Government. Towards the general public, written press is still the most important way of communication. In the first place, papers most read by decision-makers are targeted. TV is also very important, and it is an important indicator of the societal reaction. Public debates on the national channels are frequent. Scientific publications are not in the scope of the institution. Internet-based appearances (blogs, twitter, facebook etc.) are getting more importance, but this is not typical yet. A much more intensive involvement of the general public would of course be desirable; however it is limited by the availability of resources.

Case study: regulating online gambling

The following case study was selected for presentation by the NBT staff. The topic was chosen for various reasons: the societal importance of the problem, the quality of the work within the expert group, and the outcome i.e. the content and the quality of the final recommendations, which was instructive and characteristic for a case where no ideal solution could be proposed.

Selection of the topic

The topic, the problem of online gambling, leading too often to addiction, was initially identified by the secretariat of the Norwegian Board of Technology (NBT), who subsequently presented it to the Board as a project idea. The Board then discussed the idea and evaluated it according to some standard criteria (political relevance, distinct technology component, the need for political regulation etc.), and then decided to start a project.

During the initiation of project the key challenges were the following: to be able to see that the present topic (in this case: regulating online gambling) did raise interesting political issues, had a clear technology component, and it was necessary to have an idea about how the topic could be addressed through a TA-process. This part of the project did not require a high number of people, but it was a key element to be experienced in identifying and assessing potential projects. This is the reason why it was the secretariat that made most of the work in this phase.

The project was initiated because online gambling had been on a clear rise for a couple of years. At the same time the government had decided to ban “classical” slot machines in Norwegian shops, shopping malls and kiosks, as a means to reduce gaming addiction. This could have led to a further increase in online gambling, with a corresponding increase in addictive gaming behaviour. Regulations are a means to prevent addictive gambling behaviour, and the government had initiated a process on how to regulate online gambling. However, regulations are not only interesting as means to limit addictive gambling, but also because it raises more general questions about how Norwegian authorities may regulate activities on the internet and where the service provider (e.g. the provider of the online gaming site) is situated in another country where providing such services is allowed. Against this background the NBT found it interesting to assess different types of regulations and their relative merits.

Annex: Overview of NBT projects of the last three years

Together with the most important results – only if information is already available in English.

- Nanotechnology
  - o Norwegian Board of Technology recommended to the Government in its report to:
  - o Set clear commitments to what information industry must provide
  - o Implement mandatory registration
  - o Extend producer responsibility
  - o Knowledge-based management of nanomaterials for risk assessment.
  - o Introduction of specific nano-labelling
- eHealth - the Future of Ageing
  - o After a detailed analysis of the demographic tendencies and its health consequences, the report of the Board recommended
  - o Home based care technology should be offered to all users of public health care services with smart house solutions.
  - o The competence about care technology must be lifted by setting up a national advising centre.
  - o However, health care technology must be used with precaution
  - o There is a considerable need for innovation policy for the health care sector
- Youth and privacy
  - o This was an action against misuse of digital technologies (mainly internet and cell phones) including a survey on electronic bullying and harassment among young people. As a result, an educational resource material was developed together with an internet-based anti-campaign.
  - o Since 2007 the teaching material has been translated to 8 different languages and has been used by almost 1 million pupils all over the world.
- Plan B for a Norwegian climate policy
- Genetically modified plants and food
- Internet policy
- Dialogue on Science, Technology and Society
- World Wide Views on Global Warming
  - o After a whole day of discussions on climate, 100 Norwegian men and women made their own recommendations that were handed over to the Minister of Environment and International Development on 1st of October 2009.
- Education 2.0
- Business opportunities in the Internet economy
- A greener private car park – 50 % emission reduction by 2020
- A Norwegian Carbon Fund
- Synthetic biology
- Patient 2.0
  - o On 20 April 2010, the Norwegian Board of Technology handed over its recommendations for the eHealth project Patient 2.0 to the Health and Care Committee of the Parliament.
  - o The Board calls for a total digital upgrade of the healthcare system.
  - o The creation of an interactive national health web portal is recommended that should include information on health, prevention and treatment as well as self-service solutions such as

medical appointment booking, prescription renewal, access to case information and online forums.
o Patients should be granted an access to their electronic health records through a secured area of the health portal.

- The Bio-economy
- The Future of money

Denmark – DBT

Priority setting

The priority setting process of the DBT Foundation is not set yet, but is supposed to be strongly inspired by the well-functioning process of the DBT, which is described below.

Each autumn an annual agenda (work plan) was developed that set out which projects would be initiated in the coming term. The agenda ass formed in four phases:

1. All actors can give input to the agenda via the website of the DBT, and a brainstorm workshop is carried out with the Board of Representatives;
2. The secretariat ranks the input and provides a list to the Board of Governors, which then decide on a short list of topics;
3. The secretariat develop and presents each idea in a short research proposal;
4. The Board of Governors makes a final selection of projects to be initiated in the coming term and the DBT then further develops the selected project to full project designs.

The choice of topics to be dealt with by the Board of Technology as made by the Board of Governors on the basis of an open compilation of ideas through the website of the Board. Ideas may be suggested by the Board of Governors, the Board of Representatives, the secretariat, members of the Danish Parliament, the Government, authorities, researchers, organizations and private citizens. Among the 50–200 suggestions the Board received, 4–7 were selected for coming projects.

When the Board of Governors chose subjects they put emphasis on 6 criteria:

- Technology content – either in the problem or in the solution
- Is there a problem to be solved? The Board wants to contribute constructively to decision-making – not to be dealing with open scientific questions.
- Is it important? The topics have to be either of large economic importance, mean much for some people or be important for society as such.
- Is the timing right – either the topics should be of actual importance or the Board should be able to orchestrate the timing itself.
- Is there an addressee – a need-to-know? Besides such an addressee there may be a need for general dissemination or for focusing on specific target groups.
- Is it a job for the Board? Or are there other actors who would be more obvious as actors on the specific topic.

Projects were initiated by the Board of Governors on the basis of a project description embodying the adoption of the project background, concept, purpose, the method used, target groups and facilitation and dissemination, anticipated impact, project organisation, timetable and budget. When such project descriptions were provided for the Board to initiate the project, methods were specified which were appropriate for providing the needed outcomes. The Board, therefore, made use of a wide range of methods, each with specific characteristics in terms of outcomes (for example qualitative/quantitative; explorative/visionary…), involved actors (experts, stakeholders, citizens, politicians..), timing, needed resources, etc.

The Danish Board of Technology typically initiated 8-12 projects a year, 4-5 of these arising from the work plan of the Board and the rest being externally financed.

It is supposed that the DBT Foundation will build on this process, but with the Board of Representatives in a more prominent role as those who take part in developing ideas, prioritise and engage themselves in the execution and/or financing of projects.

Overview of projects

In the last three years the DBT has worked with numerous projects in many different fields, e.g. within healthcare, ICT, energy, transportation, innovation synthetic biology, waste management and many others. DBT has carried out the following projects in the last three years:

Studies (interdisciplinary scientific analyses)

- Test yourself – an overview of the supply of increasing numbers of self-test products (expert and stakeholder work group and political dialogue)
- E-voting – a choice for the future? Recommendations for implementing e-voting (expert and stakeholder workgroup and political dialogue)
- Obesity as a societal problem – an overview of political tasks related to the obesity problem (expert workgroup and political dialogue)
- A sustainable Danish transport system – scenarios and calculations on converting the transport system to renewable energy in 2050 (expert and stakeholder workgroup)
- Energy producing buildings and the engagements of citizens in energy supply and consumption (expert and stakeholder workgroup and citizens consultations)
- Hazardous substances harmful to our health – a study on high risk components and assessment of REACH (expert workgroup)
- Waste as a resource - long term planning and strategy in Denmark (expert and stakeholder group)
- Responsible Innovation – a Danish strategy (expert and stakeholder workgroup)
- Clean drinking water – challenges of the future (a citizens hearing in the Danish parliament)
- School and media – It-support for learning (expert panel)
- Synthetic biology for debate (co-work with The Danish Council of Ethics and expert workgroup)
- The Internet of Things – Internet spreading to more and smaller units with GPS, RFID etc. (workshop and public meetings)
- Technology in residential homes for elderly people – to involve the employees (cooperation with two Danish municipalities)

Participative projects (consultations aimed at gathering the views of citizens)

- Clean drinking water – challenges of the future (a Citizen Hearing in the Danish parliament)
- Citizen Summit in Kalundborg – on climate change adaption (Citizen Summit)
- Citizens Summit on Biodiversity – how to prevent the decreasing in biodiversity? (Citizen Summit)
- Citizens Summit on regional development in Northern Jutland (Citizen Summit)
- 5 Citizens Summits on the challenges of the health care system (Citizen Summit)
-

International projects

- DESSI – Decision Support on Security Investments, EU FP 7 (expert and stakeholder group)
- Technology Options in Urban Transport, STOA (panel of EU Parliament for Science and Technology Options Assessment) (interview meetings in Copenhagen, Karlsruhe and Budapest)
- Security of eGovernment Systems, STOA (panel of EU Parliament for Science and Technology Options Assessment) (case studies and conference)
- BaltCICA – Climate Change Adoption in the Baltic Sea Area, EU INTERREG (stakeholder and citizens consultations)
- ECO-efficient transport – scenarios for sustainable transport in EU, STOA (citizens consultations)
- SURPRISE – security technologies and privacy, EU FP7 (citizens consultations)
- EST Frame - societal impacts of emerging scientific and technological developments, EU FP7

- PACITA – Expanding the TA landscape in Europe, EU FP7 (wide range of methodologies)
- World Wide Views on Global warming – citizens summit in more than 20 countries
- World Wide Views on Biodiversity – citizens summit in more than 20 countries

Case study of Future Energy Systems

2004-2007: The Future Danish Energy System

In the early 2000 the frame conditions of the Danish energy sector changed due to liberalization, the international climate conventions and increased oil prices. The changes gave new challenges to the Danish energy sector.

Various actors in the energy sector expressed an interest in discussing new targets and how the Danish energy system could continue to develop under these new conditions. Some of the actors from the energy sector contacted the Danish Board of Technology to stress the need for dialogue between the politicians in the Danish Parliament and the energy sector about this situation. The actors very much underlined that companies had difficulties with long term planning because of the pressure on them to have earnings in a short term perspective. Still all energy companies and researchers needed to know something about their frame conditions and expectations of the future to be able to investigate and develop.

Initialization of the project

The Danish Board of Technology has a role to play as advisor to the Parliament and the government in technological and societal matters and decided to take up this request from the energy sector and plan a project about the Danish energy system in the future – within the time perspective of 2025.
In 2004 the Danish Board of Technology invited 10 representatives from the major actors in the Danish energy sector to participate in an investigation of possible ways forward for the structure of the Danish energy system in 2025. They represented experts and stakeholders, researchers and NGO´s and the authorities in the energy field and they were responsible for the project as a Steering Group committee.

The project was based on the method Future Panel. The Panel was composed of members from the Danish Parliament. The Future Panel operates as a short-term committee with about 20 participants, representing all political parties. The Future Panel was supported by the Steering Group committee of key experts from the energy sector and by different smaller working groups focusing on economics and energy modelling tools. The Danish Board of Technology served as secretary and method responsible for the project process.

Set up and scope of the project

The main aim was to involve the politicians in the Danish Parliament and the actors in the energy sector in a close dialogue to forward a debate about the future – and to do that on a solid ground of knowledge. Secondly the project wanted to give a concrete contribution to the political decision making process on a new national energy strategy and thirdly the aim was to make all the materials and results from the project available to a broader circle of institutions and persons – to feed a further debate and analysis on important but complicated matters in the energy field.

The project arranged 4 hearings in the Parliament. The hearings were open to public and were directed by politicians from The Future Panel. Experts from the energy field contributed to the hearings with knowledge, ideas and presentations. A solid hearing material and a short newsletter were produced after each hearing.

The project included scenario building on the future energy system in Denmark. The scenarios describe different possible directions for the energy system. Two main quantitative targets for the scenarios were set up

- to reduce the use of oil in 2025 with 50% compared to the level of 2003
- to reduce the emissions of carbon dioxide in 2025 with 50% compared to the level of 1990

It was decided to focus on technology- based scenarios to obtain the objectives in the project. The scenarios described what kind of technological mix could be used to reach the main objectives for both production and consumption of energy.

At a seminar the politicians in the Future Panel asked for a scenario that followed the main objectives in the project - reducing the oil demand and the emissions of carbon dioxide with 50 % - by strengthen a certain mix of energy savings/conservations and higher energy efficiency, using more wind power, using electric- and hybrid vehicles and bio fuels.

There was a common wish from the involved politicians and the members of the Steering Group to work with well-balanced ideas that would be regarded as a realistic and still ambitious offer with an aim that could interest the main part of the energy sector.

The politicians very much asked for a concrete scenario, easy to understand and suitable for further investigations. A working group with people from 4 different institutions (research and consultants) with expertise in energy modelling were asked to cooperate on building a new modelling tool to calculate and describe an energy scenario to meet the two main objectives.

The result should be a new flexible, not complicated energy-modelling tool, easy to communicate to others and fit for further practical use. The working group succeeded in this task and the model was reviewed by other experts in this field to be sure of the calculations and the solidness and coherency in the scenario. The new energy modelling tool was called STREAM.97 The project produced a final report of the energy scenario work.

Austria – ITA

Priority setting

Research at ITA is always organized in projects, even if not externally co-financed. ITA carries out a considerable number of projects in parallel. A medium-term research program, adapted annually, covers three years ahead (currently 2012–2014) and defines the main research areas. Proposals for new projects from the team mainly result from ITA's monitoring activities executed in parallel to the research activities. Being embedded in an international network enables ITA to detect emerging technological trends and societal problem areas at an early stage and to further develop its research portfolio continuously. A two-day workshop finalizes the annual adaptation phase. As a medium-scale institute, ITA has to select issues of priority according to its specialization and expertise, complementing the international TA scene in a meaningful way. The medium-term research program is also presented to the scientific advisory board. Board members comment on it and provide guidance to its further development.
This program is not a formally binding and thus potentially suffocating plan; rather, it provides a flexible framework for ITA's project work. In principle, the institute is free to respond to thematic calls from funding agencies or governmental bodies. Irrespective of formal external procedures like delivering proposals to funding agencies, a TA project is developed internally in a standard procedure. As a pre-condition, the research question or objectives of the new project must fit the medium-term research program. If this is the case, the internal promoter of the project brings the project idea to the weekly jour fixe and presents it to the team. After a discussion among the team members and the director's approval the project idea is being further elaborated, usually involving other partners as well.

Overview of projects and output

The current medium-term research program 2012–2014 (ITA 2011) focuses on three thematic areas, namely the information society, governance of controversial technologies, and technology and sustainability. Furthermore, an overarching research area brings together monitoring activities and critical reflection on, and further development of, TA methods.

In the area of the "information society", ITA addresses three topics. "E-governance" is a catchword indicating the potential of ICT for enabling electronic interactions within government and between citizens, private sector organizations and governmental agencies at different levels. The analyses initially concentrated on the launch of electronic administration (e-government) and currently focus on the potential and obstacles of online political participation, which can be subsumed under the concept of "electronic democracy". Under the header of "privacy", ITA analyses the relation between technologies, fundamental rights and social/political consequences as a basis for deriving options for action. The starting point and core focus of the analyses are the effects of new and future ICTs on the private sphere. The third sub-topic, "networked environments", is dedicated to the social consequences of pervasive computing and ambient intelligence. New media constitute another focus of interest, in particular the effects of their use on geographical and social structures and on modes of work in academia, especially with regard to Web 2.0 (“cyberscience”).

In the field of “governance of controversial technologies”, ITA investigates technology controversies and their significance for, and role in, the process of governance. Technology controversies have left deep traces in modern society. Disputes not only pertain to specific applications (such as in agro-biotechnology) but also to what kind of research and development is to be pursued (for instance with respect to stem cell research) and how this should be done. Current hot topics are nanotechnology as well as synthetic and system biology.

The work in the field of “technology and sustainability” has to be seen in the three-tiered framework of sustainability. An important issue is the discussion on the effects of climate change and resource shortages and the social problems they give rise to. ITA investigates and evaluates possible consequences of technologies, in particular the conditions under which a technology can contribute to sustained development. Current projects address energy technologies, climate change, ageing society and TA in engineering education.

In the following list, ITA’s recent projects are categorized into (1) research and fact finding; (2) stimulating public debate and participation; and (3) influencing political decision-making.

(1) Research and fact finding

Most of ITA’s projects fall in this category. Typically expert-driven, they gather, analyze and present facts, including technological and societal developments, and evaluate potential consequences and policy options. Recent examples include:

- Incorporating European Fundamental Values into ICT for Ageing: A Vital Political, Ethical, Technological, and Industrial Challenge (2010–2014)
- Interactive Science – Internal Science Communication Via Digital Media; Sub-project: Collaborative Knowledge Management and Democratization of Science (2008–2011)
- Integrative Analysis of the State of Knowledge Regarding Health and Environmental Risks of Nanotechnology, Including Establishing a Clearing House (NanoTrust) (2007–2013)
- Smart Response – Demand Response for Austrian Smart Grids (2010–2011)
- Communicating Synthetic Biology (COSY) (200–2009)
- eID – Systemic Change of the Identification of Citizens by Government – Electronic Identity Management as a Complex Technical Innovation and its Organizational, Legal and Cultural Matching in Selected European Countries (2007–2008)
- KB:Law|©: Knowledge Base Copyright Law (2007–2009)

Case study: “pTA Ageing” – Participative approaches for „Technology and autonomous living“

Since 1998, ITA has been involved in the implementation of internationally established instruments of stakeholder and citizens’ participation in technology policy in Austria (see above). Carefully prepared participative procedures may contribute to the public awareness of issues in science and technology. However, the prime focus of such procedures is to contribute to political decision-making using sources of knowledge other than expert knowledge. In the project „Techpol 2.0: Awareness – Participation – Legitimacy” (2005–2006), participative tools and topics were selected according to their suitability for different specific situations (see Nentwich et al. 2006).

From mid-2006 onwards, an analysis of strengths and weaknesses of participative interaction formats and of the Austrian research and technology policy with a view to finding good institutional and organizational anchors (starting points) allowed to identify appropriate topics for a participatory process. This analysis gave rise to a list of topics and appropriate tools for their application. Techpol 2:0 was the starting point for two other projects at ITA:

- Future Search & Assessment “Energy and End Users” (2007–2008) – a broad dialogue concerning the citizen-related aspects of the national energy research program “Energie der Zukunft” (Nentwich et al. 2008)

- Participative approaches for „Technology and autonomous living" (2007–2008) – a project to clarify the requirements and conditions for considering social needs and users' perspectives, and for shaping technologies at a very early phase of the technological development (Bechtold/Sotoudeh 2008). This project served as an initiator for a number other projects at ITA.

How the topic of the project was put on the agenda of ITA and why

Against the background of the human lifespan increasing in Europe, and the perspective that the number of older people will constantly grow over the next decades, the societal need to actively tackle various problems is evident. The EU Ambient Assisted Living (AAL) Joint Program was initially set up for 2008 to 2013. The program's planned total budget is 700 M€, of which approx. 50 % is public funding – from the AAL partner states and the European Commission – and approx. 50 % is funded by participating private organizations (e.g. companies)[1]. The Austrian national R&D program "Benefit" embedded in the AAL program aims at addressing these issues by boosting research and development of technology for autonomous ageing.

In the past, various studies conducted at ITA have dealt with the social needs of the ageing population in Austria (for instance, the study "Medizintechnik und Lebenshilfen fur ältere Menschen" proposed measures for improving the autonomous living of older adults; autonomous living obviously requires more than mere technological support). Between 2007 and 2008, the Austrian Research Promotion Agency (FFG) commissioned two studies on technology and autonomous living, which served to assess the results obtained under the first call of "Benefit": "Participative approaches for technology and autonomous Living I and II" (short: pTA Ageing I and II). The first study was a source of information with a view to possibly adjusting the objectives of the program and to further developing project guidelines. It was also intended to inform about future topics, relevant actors and potential pitfalls to be avoided.

[1] http://www.aal-europe.eu/

TECHNOLOGY ASSESSMENT: CONCEPTS AND METHODS

Armin Grunwald

1 INTRODUCTION

Technology Assessment (TA) constitutes a scientific and societal response to problems at the interface between technology and society. It has emerged against the background of various experiences pertaining to the unintended and often undesirable side effects of science, technology and technicisation which, in modern times, can sometimes assume extreme proportions. The types of challenges that have evolved for TA are these: that of integrating at an early stage in decision-making processes any available knowledge on the side effects, that of supporting the evaluation of the value of technologies and their impact, that of elaborating strategies to deal with the knowledge uncertainties that inevitably arise, and that of contributing to the constructive solving of societal conflicts on technology and problems concerning technological legitimisation. What characterises TA is its specific combination of *knowledge production* (concerning the development, consequences and conditions for implementing technology), the *evaluation* of this knowledge from a societal perspective, and the *recommendations* made to politics and society. TA is thus both interdisciplinary and transdisciplinary and in accordance with its research methods, it can be classified as a "post-normal science" [Funtowicz and Ravetz, 1993] and as one of the forms of "new production of knowledge" [Gibbons *et al.*, 1994].

All the various questions regarding TA concepts, methodology and content are linked to philosophy. In terms of all the normative questions that have a bearing on technological evaluation and technological design, there are close ethics of technology ties [Grunwald, 1999], as well as links with the respective branches of applied ethics (e.g., bioethics, medical ethics, information ethics). Questions on the *validity* of the available knowledge are relevant to the philosophy of science, especially in conjunction with scientific controversy, the ratio of knowledge to non-knowledge, and the divergent interpretations of the societal implications of scientific knowledge (as currently, for instance, exemplified in neuroscience). Normative and epistemic questions (knowledge and values) are often interwoven, like for instance, when it comes to the application and consequences of the precautionary principle [Harremoes *et al.*, 2002; Schomberg, 2005]. Many TA topics are,

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furthermore, pertinent to the philosophy of technology or are anthropologically relevant, such as questions regarding the man-machine interface, the substitutability of human beings by robots, the increasing degree to which living beings are being penetrated by technology, or the "technical enhancement" of human beings [Roco and Bainbridge, 2002; Grunwald, 2007a].

An overview of TA is first given (Section 2). TA is introduced in a problem-orientated fashion by presenting the societal needs it sets out to address. The historical background to TA is then sketched on the basis of the proposed and realized TA concepts and the spectrum of methods employed in TA. The central TA challenge lies in treating the normative dimensions of technology. An entire section (Section 3) is therefore devoted to this aspect. The final section (Section 4) gives an overview of the current TA developments and of the requirements for the foreseeable future.

2 TECHNOLOGY ASSESSMENT: AN OVERVIEW

The term "Technology Assessment" (TA) is the most common collective designation of the systematic methods used to scientifically investigate the conditions for and the consequences of technology and technicising and to denote their societal evaluation. At first sight, entirely heterogeneous activities are subsumed under this name, such as the predicting of the consequences of technology, the communicating of risk, promoting innovation, improving the legitimacy of decisions on technology through increased participation [Joss and Belucci, 2002], mediating in technological conflicts, and observing sustainability. The problem met in defining TA consists in the fact that it is not *a priori* clear what the common denominator of such heterogeneous efforts should be. No consensual, unambiguous and selective definition of TA has yet been provided. As the emergence and development of TA are closely connected with specific situations arising at the interface between technology and society, these same situations form the central background to the introducing and clarifying of TA.

2.1 The historical origins of technology assessment

TA arose from specific historical circumstances in the 1960s and 1970s. The US congressional representative Daddario is now held to be the coiner of the term and of the basic theory underlying TA [Bimber, 1996], which culminated in the creation of the Office of Technology Assessment (OTA) at Congress in 1972 [United States Senate, 1972]. The concrete background consisted in the asymmetrical access to technically and politically relevant information between the USA's legislative and executive bodies. While the executive, thanks to the official apparatus at its command, was able to draw on practically any amount of information, parliament lagged far behind. This asymmetry was deemed to endanger the — highly important — balance of power between the legislative and the executive facets of technology-related issues. From this point of view the aim of legislative TA was to restore parity [Bimber, 1996].

Parallel to this very specific development, radical changes were taking place in intellectual and historical respects, which were to prove pivotal to TA. First and foremost, the optimistic belief in scientific and technical progress, which had predominated in the post Second World War period, came under pressure. The ambivalence of technology was a central theme in both the Critical Theory of the Frankfurt School (Marcuse, Habermas) and in the Western "bourgeois" criticism of technology (Freyer, Schelsky) with its dialectical view of technological progress: "the liberating force of technology — the instrumentalisation of things — turns into a fetter of liberation; the instrumentalisation of man" [Marcuse, 1966, p. 159].

At the same time, broad segments of Western society were deeply unsettled by the "Limits of Growth" [Meadows *et al.*, 1972] which, for the first time, addressed the grave environmental problems perceived as a side effect of technology and technicisation, and by discussions on technical inventions in the military setting forecasting the possibility of a nuclear attack that would put an end to humanity. 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 crisis surrounding the optimistic belief in progress, TA would presumably never have developed or, more precisely, would never have extended beyond the modest confines of the above-mentioned US Congressional office.

Furthermore, the legitimization problems linked to technologically relevant decisions have been crucial to the genesis of TA. Problems with side effects, the finiteness of resources and new ethical questions have all heightened decision-making complexity and have led to societal conflicts on the legitimacy of technology. The planning and decision-making procedures developed as early as the 1950s in the spirit of planning optimism [Camhis, 1979] turned out to be clearly unsuited to solving this problem. In addition, the technocratic and expertocratic character of these procedures became an issue in a society in which the populace and the media was starting to monitor democracy and transparency more closely [van Gunsteren, 1976]. Demands for a deliberative democracy [Barber, 1984] led to a climate in which it was particularly the critical aspects of scientific and technical progress that started being debated in the public arena.

The move away from metaphysical and philosophical assumptions about technology also instigated the emergence of TA, a field that focuses on the criteria and means underscoring the concrete development of technology in concrete historical contexts, the conditions facilitating the malleability of technology in society, and the relevant constraints. In the post-metaphysical world [Habermas, 1988a], it is no longer a matter of humanity's technology-driven liberation from work constraints (Marx, Bloch) or of humanity's "salvation" thanks to engineering intervention (Dessauer), neither is it an issue of man's deplored "one-dimensionality" in a technicised world (Marcuse), of the "antiquatedness of man" in sharp contrast to the technology he has developed (Anders) or of fears of a technologically-induced end to human history [Jonas, 1979]. It is more about the impact of technology and the concrete design of specific technical innovations, for instance, in transportation, in information technology, in space flight and in medicine. TA does not concern itself with technology as such but rather with concrete technical products, processes, services, systems, and with their societal impacts and relevant general settings.[1] These developments are reflected in the philosophy of technology where more emphasis is placed on empirical research [Kroes and Meijers, 1995].

The problems mentioned at the outset about the effect that parliamentary decision-making has on technology only give the "occasion" for the initiation of legislative TA facilities, not the deeper reasons for TA formulation which are rooted in the experience of ambivalence towards technical progress, in problems surrounding technological legitimacy in a society with increasing demands for participation, and in the need to concretise and contextualise technology evaluation in complex decision-making situations. The occurrence of TA is thus one of the very specific descriptors rendering our historical situation one that may be dubbed "reflective modernity" [Beck *et al.*, 1996].

2.2 TA as a response to societal challenges

The social climate of the 1960s and 1970s led to a specific TA requirements profile, which is, to a large extent, still relevant today, though new expectations and requirements continue to emerge.

2.2.1 The mounting implications of science and technology

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. Examples are the increasing intervention in the natural environment as a result of economic activity and man's increased interference — through scientific and technical progress — in his own social and moral traditions and ultimately also in his own biological constitution [Habermas, 2001]. Technological progress alters social traditions, fixed cultural habits, 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, fan the flames of technological conflict, challenge value systems, create new societal "states of mind" and even change

[1]This contextualization is occasionally criticized on the grounds that TA delves too deeply into the details of technical development so losing sight of the "broader questions" relating to technology, society and the shaping of the future. In this process also the degree of critical distance needed could be lost.

human nature [Roco and Bainbridge, 2002]. New and emerging technologies are not only a means of realizing new technical functions they are also "indicators of the future" [Grunwald, 2006a], on the basis of which society arrives at an understanding of non-technical questions like those relating, for example, to changes in the conceptions of humanity or new societal orders. In this respect, there is close affinity between many TA problems and the great philosophical questions, even if the former concern themselves with the details of technical innovations.

The considerably increased influence of science and technology earns such problems more attention both in politics and from the public point of view and they become the subject of critical reflection. This directly concerns technological side effects but increasingly also the entire direction of technological progress. TA has an important function when it comes to discussing and advising, in a knowledge-based and ethically reflective manner, the possibilities and/or necessities of the *social shaping of technology* [Yoshinaka *et al.*, 2003], establishing informed democratic opinion [Fisher, 1990], creating a *knowledge policy* [Stehr, 2004], or encouraging *sustainable development* [Ludwig, 1997; Grunwald and Kopfmüller, 2006].

2.2.2 Side effects and precaution problems

Since the 1960s the adverse effects of scientific and technical innovations have been considerable and some of them were of dramatic proportions: accidents in technical facilities (Chernobyl, Bhopal), 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., labour market problems caused by productivity gains) and the intentional abuse of technology (the attacks on the World Trade Centre). This list illustrates why many optimistic expectations relating to future technological progress have currently been abandoned. The rising range of negative effects in time and space, reaching even a "global" technological level, emphasises the relevance of all of this. In part, even the perception of technology has been dominated by a fear of apocalyptic threats to humanity's continuity (for example, [Jonas, 1984]). Playing down the side effects by referring to them as "the price of technical progress" can cause people to really question the positive aspects of technology.

This experience with such unexpected and in some cases 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 has always had a prominent place in TA discussions from the very beginning [Paschen and Petermann, 1991, p. 26].

The increasing *complexity of technical systems,* their diverse interlacing, and their connectivity with many areas of society increases the difficulties of being able to predict and consider the consequences of actions or decisions. This applies on the one hand, for example, to the infrastructure technologies, particularly in the fields of transportation, energy, and water, which are closely allied to habits, consumption patterns, and societal institutions. On the other hand, due to the vast number of interfaces that have to be taken into consideration, the new cross-sectional technologies such as nanotechnology tend to broaden the spectrum of the possible side effects that have to be included in decisions concerning these technologies thereby increasing the related uncertainty.

This situation leads to a societal and political *precautionary problem*: 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 stockpile knowledge 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] —, dealing with genetically modified organisms, or the unknown consequences of the accumulation of non-degradable chemicals in the world's oceans, especially in the polar regions (for further examples, cf. Harremoes *et al.* [2002]). In order to be able to cope rationally with these situations of little or no knowledge of certain 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 [Schomberg, 2005]. Precautionary problems of this type are a classic field of TA.

2.2.3 The ethical questions of technical progress

For a long time, the question of whether technology had any morally relevant content and could, therefore, be a subject of ethical reflection at all was a controversial topic. Well into the 1990s, technology was held by many, in particular scientists and engineers, to be *value free*. Since then, the value content of technology has been revealed, and the normative backgrounds of decisions on technology (both in design and in the laboratory) have been recognized in numerous case studies and made the subject of reflection (e.g., [Winner, 1980; Mitcham, 1994; van de Poel, 2001; van Gorp, 2005]). The basis for this development is to view technology less as a set of abstract objects or procedures but more as embedded in societal processes and to take it seriously. Technology is not nature; it does not emerge of its own accord but is instead produced to satisfy goals and purposes. Technology is, then, always already embedded in societal intentions, problem diagnoses and action strategies. Because of the side effects mentioned above, the entire field of ethical questions of risk acceptance and acceptability comes into play. In this sense, there is no such thing as a "pure" technology, divorced from society.

It has thus now been acknowledged that technology comprises values and is a legitimate object of responsibility in the normative sense (cf. for example, van Gorp and Grunwald [2007]). The moral criteria employed (that is to say whether something should, would, could, might or must be) clearly differ according to the group concerned, be they manufacturers, operators, users, or those affected directly or indirectly. Tasks requiring ethical reflection present themselves precisely whenever the judgement of various actors leads to diverging results and makes moral conflicts manifest [Grunwald, 2000]. A number of serious ethical questions have been raised, especially as a result of innovations in the modern life sciences, and have also become the subject of public debate. These questions relate particularly to reproductive cloning, reproductive medicine, stem cell research and the "technical enhancement of human beings" [Roco and Bainbridge, 2002]. Nowadays, there is thus hardly any doubt that TA must also inevitably concern itself with normative questions which means that in this way it becomes closely connected to ethics [Grunwald, 1999].

2.2.4 Technology conflicts and problems of legitimisation

Societal conflicts relating to science and technology are not unusual; they are inherent to any pluralistic society. Answers to questions about the desirability or acceptability of technology, about whether technological risks are acceptable or about where precisely the ethical limits of technology lie are generally controversial due to social pluralism, the differing degrees to which different groups in the modern world are affected by various technological impacts, diverging interests and people's differing moral convictions. Images of the future, desires and fears, visions and scenarios are also usually contested [Brown *et al.*, 2000]. 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 legitimisation* 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 neighbourhood will have to accept more disadvantages than others. Problems of legitimisation 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 legitimisation is obviously important. Many examples can be given such as: opposition to nuclear power, the problem of expanding airports, the problem of how to dispose of radioactive waste, the release of genetically modified plants, and regional and local conflicts on waste disposal sites, waste incineration plants, or the location of chemical processing facilities. In these areas, political decisions are frequently not accepted by those affected or by the general public, even though they are the result of democratic decision-making procedures.

The differentiation of modern societies, their fragmentation into plural groups with different moral convictions, and the cultural heterogeneity increased by migration and globalization all make it difficult to achieve a general consensus on technology. As demonstrated above by the nuclear technology examples (atomic reactors, reprocessing plants, the transportation and disposal of radioactive waste), conflicts on technology and its lack of acceptance in society have led to situations which virtually lead to a societal standstill. This is precisely where the danger lies: the escalation of conflict on technology can lead to a hardening of fundamentalist positions which, in turn, can be an obstruction to finding pragmatic solutions to problems and can sometimes almost even lead to civil war. The challenge to society consists in dealing with the conflicts in such a way that the resulting decisions are acknowledged as legitimate, even if they run counter to the interests, values, and preferences of some parties. In particular it is participative TA procedures that try to provide solutions to this problem (Section 2.4.2).

The solving of problems allied to legitimisation and technology conflicts is complicated by a certain public mistrust of decisions made by experts that has been growing for decades. Frequently a situation arises in which expertise and counter-expertise conflict thus invalidating in the eyes of the public the expertise of scientific authorities. Scientists are not only — as their traditional self-understanding dictates — incorruptible advocates of objective knowledge, but they are also interested parties in their own cause, lobbyists for external interests, or committed citizens with political convictions, not all of which can always be kept clearly separated from their professional position. In addition to this the political system is perceived to be less and less of a trustee of citizens' interests, and increasingly interested in its own gain. Methods for solving problems of legitimisation therefore basically involve more frequently integrating non-experts [Fischer, 1990]. New forms of legitimisation (through participative TA, [Joss and Belucci, 2002]; cf. Section 2.4.2 of this contribution) and solutions to specific problems in the communication between experts and non-experts [Bechmann and Hronsky, 2003] therefore belong to the spectrum of TA responsibility.

2.2.5 Economic difficulties and prerequisites for innovation

From the outset, TA has been an aspect of the national innovation system. If, in the initial phase, it was primarily a question of providing an early warning on technological risks, this was not so much done to hamper new technologies as to open up opportunities to avoid or overcome such risks by detecting them early on. The early detection of risks fits into the tradition of deploying the innovation potentials of science and technology as "well" as possible. For this reason, another TA topic that emerged early on was the early detection of technological *opportunities* so that the best possible use could be made of these benefits and so that the benefits and hazards could also be rationally determined. The search for opportunities and possible innovative applications of technology is an inseparable aspect of TA [Ayres *et al.*, 1970; Smits and Leyten, 1991].

Since the 1990s, new challenges have arisen. In many national economies, serious economic problems have cropped up, which have led to mass unemployment and to the accompanying consequences for the social welfare systems. Increased innovativeness is said to play a key role in solving these problems. On the basis of this analysis, new functions have been ascribed to TA within the scope of innovation research [Smits and Den Hertog, 2007]. Its basic premise is to involve TA in the design of innovative products and processes because innovation research has shown that scientific-technical inventions do not automatically lead to societally relevant and economically profitable innovations. The "supply" from science and technology and the societal "demand" do not always correspond. This means that more attention has to be paid to more pronouncedly orienting towards society's needs within the scientific-technical system, the diffusion of innovations and the analysis of opportunities and constraints.

The theoretical question as to how economic conditions contribute to the success or failure of technical innovations demonstrates that TA takes an active interest in the relevant societal background. Cultural and social questions are also seen as relevant factors for innovations. Including users in technology design, in order to better link technical proposals and consumer demands, should also be mentioned here [Smits and Den Hertog, 2007].

2.3 General characteristics and definition of TA

The above-mentioned facets of the diagnosis of societal developments in the past decades form the problem background against which TA was formulated, and the solution to which it is supposed to contribute. Depending on the context, corresponding societal expectations present themselves in a specific form, and show considerable heterogeneity. In spite of the diversity stimulated by this situation the general characteristics of TA can nonetheless be listed:

- *Orientation on Advice and Decision-Making*: TA supports public opinion and public participation in decisions on science and technology. In this endeavour, it aims at embedding TA knowledge and orientations into the perspective of decision makers: TA knowledge is knowledge for those who are to be advised. Because decisions always affect the future, a reference to the future is always included. TA always functions *ex ante* with regard to decisions.

- *Side Effects*: In TA, it is a matter of combining "comprehensive" decision support with the widest possible contemplation of the spectrum of foreseeable or presumable effects. Beyond classical decision theory, which establishes the relationship between goals and means according to the viewpoint of efficiency, TA turns its attention to unintentional side effects as a constitutive characteristic [Bechmann *et al.*, 2007].

- *Uncertainty and Risk*: Orientation to the future and the problems posed by side effects often leads to considerable uncertainty regarding TA knowledge. TA therefore always has to do with providing decision-making support in conjunction with complex innovations under conditions of uncertainty. The impact of such decisions is difficult to predict.

- *Value-Relatedness*: The rationality of decisions not only depends on knowledge about the systems involved and of the available action-guiding knowledge, but also on the basic normative principles. The disclosure and analysis of the normative positions involved is therefore also an aspect of the TA advisory service (e.g., depending on ethical reflection or sustainability evaluations [Grunwald, 1999; Ludwig, 1997]).

- *Systemic Approach:* TA aims at achieving a comprehensive view of the fields affected. Several perspectives, e.g., from different scientific disciplines, have to be integrated into a coherent picture. Specific attention is dedicated to the systemic interrelationships between the impact of technology in different societal areas.

- *Broad Understanding of Innovation:* TA understands a broad notion linked to the term "innovation". Beyond the mere technical understanding of innovations as new products or systems, TA contemplates social, political, and institutional innovations and does, in general, also consider socio-technical innovations.

- *Thinking in Alternatives*: When working on concrete projects, TA does not confine itself to a certain technology but always operates in an open window of possible alternatives. Presumed inherent necessities are broken down so that leeway for structuring can be gained. In concrete processes, the question of whether the results desired could not also be realized in a different manner is always posed. Alternative options are thus also examined which are not based on technology, but concern the political planning measures. "Thinking in alternatives" has thus become a specific TA tradition.

- *Interdisciplinarity and Transdisciplinarity*: TA concerns itself with complex societal problems that affect technological decisions and technological side effects. It does this on scientific grounds backed up by research. As a rule, such problems are worked on in an interdisciplinary or transdisciplinary manner.

- *Time Limitation*: Deadlines for completion of the analyses and studies are also inextricably intertwined with the decision-making process. TA knowledge has to be available at certain times regardless of whether all desiderata for comprehensive and reliable knowledge can be satisfied. Without this pragmatic limit, TA's claim to provide analyses that are as comprehensive possible could lead to never-ending stories.

Now that the main characteristics have been listed we shall introduce TA in a problem-orientated fashion according to its societal responsibilities in the providing of specific knowledge and advisory services. We can draw on the existing definition of TA which states that: "Technology Assessment (TA) is a scientific, interactive, and communicative process which aims to contribute to the formation of public and political opinion on societal aspects of science and technology" [Decker and

Ladikas, 2004]. This definition stresses that TA *contributes* to problem-solving, but does not pretend to provide actual solutions. TA provides knowledge, orientation, or procedures on how to cope with certain problems at the interface between technology and society but it is neither able nor legitimized to solve these problems. Only society can do this, through its institutions and its decision-making processes. There is, therefore, a constitutive *difference between advising and deciding.*

The definition given above also includes the attribute "societal" which specifies that the public and political sphere is the place for discussing and dealing with the relevant effects of technological impact. TA is concerned with the aspects of technology that have *societal* implications. Here the focus of TA dwells in the perspective of *unintended side effects*. Accidents, environmental impact, unintended side effects on social life (e.g., in employment) and other technological consequences that were neither intended nor anticipated are some of the most important issues in modern times. TA has also been set up as a societal means to enable such situations to be dealt with constructively while making use of scientific research [Bechmann *et al.*, 2007]. Early warning, sustainable development, and the precautionary principle are relevant notions here.

An international community has been formed around the concept of TA roughly sketched above [Rader, 2002; Vig and Paschen 1999]. Part of this community works in institutions explicitly devoted to TA (e.g., to provide advice on parliamentary policy) and its organizations (cf., for instance, the European Parliamentary Technology Assessment Network EPTA, www.eptanetwork.org), part of it is organized in networks (cf., e.g., the German-language network TA, www.netzwerk-ta.net), and another part converges on the fringes of disciplinary organizations and conferences, such as in sections of professional sociological or philosophical organizations, or in the social scientific STS Community (Science and Technology Studies), e.g., under the auspices of EASST (the European Association for the Study of Science and Technology), and of many IEEE (Institute of Electrical and Electronics Engineers) activities relating to the social implications of technology.

2.4 Concepts of technology assessment

Fulfilling TA's above-mentioned responsibilities and satisfying the societal expectations behind those responsibilities requires an operable framework including different facets, typically research concepts, knowledge-dissemination models, task concepts for dedicated TA institutions, or ideas on public discourse and TA's role within that. TA concepts exist at the uppermost level of TA operationalisation since they reduce the complexity of the entire collection of requirements to the focal points determined in each case.

Throughout its history, TA has undergone a series of metamorphoses. Societal trends and research directions such as planning optimism or scepticism, positivism and value orientation, social constructivism and research into the genesis of technology, participation and civil society, loss of confidence in expert decisions, and concepts such as the Risk Society, the Network Society, and the Knowledge Society, economic globalization, the discussion on the uncertainty of knowledge, new forms of knowledge production [Gibbons *et al.*, 1994], and the guiding principle of sustainable development have all made their mark on TA. For more than 30 years some complementary, some competing, and some TA concepts that were adapted to varying requirements have been developed in this manner. The concepts of TA presented below are intended to provide the most varied impression possible of TA's conceptual diversity.

2.4.1 The "classical" concept of TA

The classical concept of TA is an ex post facto construct. It does, in fact, incorporate aspects of the way in which TA was practised during its "classical" phase in the 1970s, in the Office of Technology Assessment (OTA) at the US Congress [United States Senate, 1972; Bimber, 1996] but in many respects it is a later stylization and not an adequate historical reconstruction. Nonetheless, it is useful to recall the elements of this classical concept, particularly as delimitations and re-orientations can be more clearly described against this backdrop. The following (partially normative) six elements are deemed to be constitutive for the classical conceptualisation of TA:

Positivism: TA in the classical sense is dominated by a *positivistic understanding of science*. It designates a method of producing "exact, comprehensive, and objective information on the technology, in order to facilitate the deciders' effective societal commitment" [United States Senate, 1972]. In the foreground and elaborated for the deciders' purposes is the description of what is technologically state- of- the- art and the presumed consequences thereof. Recommendations or independent judgements remain reserved for the political sphere; they are not the domain of TA. The OTA gives "no recommendations, what should be done, but rather...information about what could be done" [Gibbons, 1991, p. 27]. The positivistic legacy of TA that "OTA never takes a stand" [Williamson, 1994, p. 212] is derived from the postulate of science being value free (Weber). The classical concept corresponds in this manner to a *decisionist* division of labour between positivistic TA and the planning preserve of politics: TA provides purportedly value-free knowledge about technology and the impact of technology while the political system evaluates this knowledge and makes decisions.

Etatism: In the classical view TA is exclusively perceived to provide *advice to politics*. This is founded on the assumption that the state has the authority to direct technology in a societally desired direction: the state can procure the necessary knowledge about impacts; it represents the public interest, as opposed to citizens' preferences and interests, and it is the central planning authority empowered to actually implement intentions and programs of societal management. This etatist interpretation of the state is characteristic of the period of planning optimism [Camhis, 1979] when TA was established. This fixation on the state in the early phase of TA has since met with harsh criticism (e.g., [van Gunsteren, 1976]) which has motivated the development of more participatory TA approaches.

Comprehensiveness: TA in the classical sense aims at *comprehensiveness* with regard to the consequences of the technology to be studied. The hope is that a complete record of the effects of a technology will help society to avoid unpleasant surprises during its introduction and in the automation of processes. In a certain respect, this assumption is the legacy of former planning optimism. According to this view there must be complete knowledge of all the data on the problem to be decided — and a complete knowledge of all the side effects — in order to eliminate uncertainties. In earlier conceptions, people tried to fulfil this demand for completeness through system analysis [Paschen *et al.*, 1978]: the side effects of technology are often the result of a systemically reticulated process with nonlinear cause-and-effect relationships and interactions which are difficult to discern.

Quantification: In this approach there were also great expectations regarding the *quantitative apprehensibility* of the effects of technology. It was expected that systems theory would, in combination with the quantification of social regularities, prepare quantitative models of causal chains and laws of societal processes and, thus, "objectivise" them. This approach also harboured the expectation that the problem of subjectivity (or of lack of inter-subjectivity) in evaluations of the effects of technology could be solved by means of quantification (see Section 3.2 for limitations on this expectation).

Prognosticism: TA in the classical interpretation was seen, above all else, as a *prognostic determination* of the impact of technology and as an early warning mechanism for technologically caused risks. In analogy to a prognosis based on natural systems, the laws of societal processes were to be discovered and used for quantitative prognoses, which should be as exact as possible. Trend extrapolations and assumptions about laws should therefore make it possible to extrapolate an empirically recorded series of relevant parameters into the future. Such prognostic knowledge should then enable the political system to react appropriately and promptly and, if the situation arose, to take countermeasures against hazards.

Orientation towards experts: The classical concept of TA is orientated towards TA *experts*. They must provide the necessary knowledge and communicate with decision-makers by offering political advice. In contrast to the various models for participative TA (see below), classical TA is deemed to be focussed on experts, hence the coining of the sometimes-used term "expertocratic".

2.4.2 Participative technology aAssessment

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; Habermas, 1988b; Renn and Webler, 1998]. Problems of evaluation were a driving force behind this demand since according to ideas derived from the theory of democracy (e.g. [Barber, 1984]), evaluation should not be left solely to the scientific experts (expertocracy) or to the political deciders (decisionism). It is the task of participative TA to include societal groups — lobbyists, affected citizens, non-experts, and the public in general — in the process of evaluating technology and its consequences. In this manner, participative TA procedures are deemed to improve the practical and political legitimacy of decisions on technology [Paschen *et al.*, 1978, p. 72]. Such TA is informed by science and experts and, in addition, by people and groups external to science and politics [Joss and Durant, 1995; Joss and Bellucci, 2002].

The demand that those affected participate in decisions on technology has been increasingly put into practice since the1980s, beginning in the smaller, traditionally discursive western and northern European nations, such as Denmark and the Netherlands. Participation has gained particular relevance, on the one hand, in many discussions on technological locating (e.g., airport expansion, waste disposal sites, chemical processing plants, final disposal sites for radioactive waste), in which the widespread NIMBY (Not In My Back Yard) problem leads to participation being emphatically needed [Renn and Webler, 1998]. On the other hand, participation became a constitutive feature of the so-called "Foresight" processes [Martin and Irvine, 1989] in which, for example, the agenda for research policies and for promoting technology, was set or visions for the development of certain regions were formulated [FOREN, 2001].

The participation of citizens and of those affected is believed to improve the knowledge as well as the values on which judgements 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 location. Furthermore, in a deliberative democracy, it is necessary to take the interests and values of *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 [Joss and Belucci, 2002].

The participation in TA of those affected by technology is designed to improve the legitimacy of ensuing decisions and thus prevent conflict. The expectation is that when those affected have had the opportunity to present their arguments and to weigh them against those of their opponents, they are more likely to acknowledge the resulting decisions as legitimate and accept them, even if such decisions run counter to their own interests. For many, participative TA is also supposed to counteract the political disenchantment observed in many countries and "empower" those affected. The model of representative democracy, which is threatened by emaciation, is confronted here with a civil-societally renewed democracy [Barber, 1984].

These ambitious objectives are, however, hard to realize in practice [Grunwald, 2004b]. Not only representative democracy but also participatory TA is confronted with the problem of representation: only a few people can attend such meetings but they should represent all the relevant groups. The willingness to engage in participatory TA varies according to the population group and correlates with the level of education. The relation between participatory processes and the usual democratic decision-making processes remains an unresolved issue in many countries and this endangers the relevance of participatory TA.

2.4.3 Constructive technology assessment (CTA)

The basic assumption of CTA, which was developed in the Netherlands [Schot, 1992], 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 Collingridge dilemma [Collingridge, 1980], once the impacts are relatively well-known, the chances of influencing them will significantly decrease. It would therefore be more effective to accompany the process of the *development* of a technology constructively (similarly to the idea of a "real time" TA, cf. [Guston and Sarewitz, 2002]). The origin of technological impact is traced back to the development phase of a technology so that dealing with the consequences of technology becomes a responsibility that already starts in the technology design phase.

The theoretical background to CTA is the Social Construction of Technology (SCOT) program, which was also developed in the Netherlands and which has been elaborated in a number of case studies [Bijker *et al.*, 1987; Rip et al., 1995]. According to this approach, the development of technology should be perceived as the result of societal processes of meaning giving and negotiation. Technology is "socially constructed" during these steps. CTA has pleaded for the early and broad participation of societal actors, including key economic players and for the establishment of a learning society that experiments with technology. In the normative respect, CTA builds on a basis of deliberative democracy in which a liberal picture of the state highlights self-organising processes in the marketplace. To this end, three processes have been proposed (according to [Schot and Rip, 1997, p. 257f.]):

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. The options are, however, restricted. CTA therefore also addresses other actors (banks and insurance companies, standards 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.

Strategic Niche Management: Governmental promotion of innovations 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, make use of processes of learning, gain acceptance, and finally —

it is hoped — maintain its own in free competition unaided by public support. This approach, in which the state directs technology close to the market, is especially relevant in fields reluctant to embark on innovation, such as infrastructure technologies. Successful implementation presupposes considerable learning processes and careful observation of developments either to avoid exposing "niche technology" to competition too early, thereby endangering its growth, or to prevent prolonged subsidies leading it to miss the moment of its marketability.

Societal Dialogue on Technology: It is necessary to create the opportunities and structures for critical and open dialogue on technology. In the process, one has to go beyond the limits of scientific discourse and expert workshops to include the economy and the populace. This applies to technology forcing as well as to niche management. "Managing Technology in Society" [Rip *et al.*, 1995] is possible only when these elements harmonise.

2.4.4 Leitbild assessment

In Germany, the concept of empirical technology shaping research developed in parallel with CTA [Dierkes *et al.*, 1992; Weyer *et al.*, 1997]. As in CTA, the paramount objective is to analyse the shaping of technology and its "enculturation" by society instead of reflecting 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, analysing 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.

Leitbild assessment [Dierkes *et al.*, 1992] has made it clear that technology development often follows non-technological ideals. Leitbilder ("guiding visions", cf. Grin [2000]) are often phrased in metaphors which are shared, implicitly or explicitly, by the relevant actors (e.g., the "paperless office", "warfare without bloodshed", or the "automobile city"). Research into such ideals has investigated in detail, empirically and hermeneutically, which mechanisms dominate this development, including linguistic analysis of the use of metaphors in engineering circles [Mambrey and Tepper, 2000]. The expectation is that through societal construction of the ideals shaping it, technology can be indirectly influenced in order to prevent any negative effects.

These deliberations have led to a wealth of instructive case studies [Weyer *et al.*, 1997], but they have not really been integrated into TA practice. The reason probably lies in the fact that strong assumptions are necessary for the transfer of knowledge gained *ex post* in case studies on TA problems, which are always inevitably concerned with the future. *Leitbild* assessment is a way of explaining the course of technology development *ex post* rather than by giving indications on how to shape technology. Moreover, the sociological perspective has resulted in the neglecting of the normative dimension of technological shaping.

2.4.5 Innovation-orientated technology assessment

Embedding technology in society takes place by means of innovation. There are thus overlaps between TA and innovation research and in recent years the two fields have developed "innovation-orientated" TA concepts at their interface [Smits and Den Hertog, 2007]. Innovation research focuses on the analysis of completed and current innovation processes and is primarily interested in factors that are crucial to successful market penetration. Factors enabling and preventing innovative success are identified. The objective is to attain a better understanding of innovation processes and their influencing factors. With this knowledge, governmental research and technological policies, as well as industrial decisions on innovations can be supported.

In this respect TA first contributes, by broadening the spectrum of influencing factors, by adding social and cultural elements. TA then examines — analogous to participative TA — the role of the users in innovation processes. In innovation-orientated TA, a special role is assigned to the users whenever customer-orientated and social technology designs are at stake. In order to realize this objective, the users must be included in the early phases of technology development [Smits and Den Hertog, 2007]. The classical instruments of market research are inadequate for this purpose. Instead, users have to be integrated into deliberative and prospective processes of technology prognosis (foresight). In this respect, they can play very different roles. "Users can play a role as more or less active consumers, and modifiers, as domesticators, as designers, and, in fact, also as opponents of technological innovation. ... High quality user-producer relations as well as possibilities for learning and experimenting are prerequisites for successful innovation processes" [Smits and Den Hertog, 2007, p. 49]. To this end one important function for TA is to identify the relevant actors in a certain field, to inform them and then, most importantly, to use discursive procedures to establish the users' needs, visions, interests and values. It is then a question of integrating these findings into the process of technology development. Innovation-orientated TA should thus contribute to making the regional or national innovation systems more strongly orientated towards citizens' and consumers' needs [Smits and Den Hertog, 2007].

2.4.6 Technology assessment and engineering ethics

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 de Poel, 2001; van Gorp, 2005]; cf. also the chapter on values and design by Ibo van de Poel, this Handbook, Part V). Decisions on technology design involve value judgements. There is, in other words, a close relationship between professional engineering ethics and the ethics of technology [Mitcham, 1994]. By way of example, one can cite VDI guideline no. 3780 of the Association of German Engineers [VDI, 1991], 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 premiss [VDI, 1991, p. 7]: "It should be the objective of all technical action ... to secure and to improve human possibilities in life." They are involved in technology development when observed by engineers in practice, that is to say, they are virtually *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.

2.5 Methods in TA

Methods assume a central function in TA to fulfil its responsibilities in research, assessment or advice. The guaranteeing of the transparency, comprehensibility, and inter-subjectivity of TA results is primarily ensured, as in the classical scientific disciplines, by the ability to follow the materialisation of the results step by step as the method proceeds. The use of methods is closely allied to TA's observance of quality standards [Decker and Ladikas, 2004]. TA requires specific methods or method sets which are tailored to the relevant assignments, backgrounds and actor constellations. In TA methods can be used to collect data, provide knowledge, organize TA-relevant communication, gain ideas on conflict management, uncover the normative structure of technology conflicts, establish scenarios on future developments or assess value structures.

In order to operationalise TA activities in specific projects, a set of methods is available in the form of a "method toolbox" (see Decker and Ladikas [2004]). A first step in designing a TA project is to select appropriate methods and clarify their integration in a coherent mix relevant to the overall project goals and the specific environment. Often the specific goals of a TA project can only be attained by combining different methods or adopting new ones. The needs and expectations of the respective beneficiaries will, of course, influence the set of methods chosen, because TA knowledge has to be "customised". The project design also takes general TA quality criteria into account such as scientific reliability or interactive fairness. The project design is influenced by the institutional setting, the mission of the institution, its tradition or history and its formal status. Careful "situation appreciation" must therefore be carried out *in advance* to identify which methods are appropriate [Bütschi *et al.*, 2004]. The methods applied in TA are research methods, interactive methods and communication methods [Decker and Ladikas, 2004].

Research methods are developed in disciplines pertaining to the sciences and humanities. They are applied to TA problems in order to collect data, to facilitate predictions, to do quantitative risk assessment, to allow for the identification of economic consequences, to investigate social values or acceptance problems and to do eco-balancing. This class of methods includes (1) modelling, systems analysis, risk analysis (cf. Section 3.3.1), material flow analysis (cf. Section 3.3.3) (to understand the sociotechnical system being investigated as well as to be able to assess the impacts of the political measures proposed); (2) trend extrapolation, simulation, scenario building (to create systematic knowledge in order to contemplate the future); (3) the Delphi method (to gather expert knowledge, especially on the assessment of future developments in science and technology); (4) expert interviews and expert discussion (to gain more insight into current situations but also to analyse scientific controversy and diverging assessment with respect to the arguments used); (5) discourse analysis, values research, ethics, and value tree analysis (for the evaluating and revealing of the argumentative landscape in normative respects).

Interactive, participatory or dialogue methods are developed to organise social interaction in such a way as to facilitate conflict management, allow for conflict resolution, bring scientific expertise and citizens together, involve stakeholders in decision-making processes and mobilise citizens to shape society's future. This class of methods includes (1) consensus conferences (to involve citizens in societal debate on science and technology in a systematic manner, according to a specific framework (cf. Sect. 3.3.5)); (2) expert hearings (to inform the public but also to confront experts with laymen's views and with diverging expert judgement); (3) focus groups (to gain coherent views on a specific topic from a set of actors and citizens); (4) citizens' juries (to assess measures and planning ideas with respect to the values and interests of stakeholders and interested parties); (5) scenario workshops and perspective workshops (to create drafts of the future in an interactive way).

Communication should be seen as a two-way process. On the one hand communication methods are used to communicate the corporate image of a TA institute, the TA approach, the TA process and the TA product to the outside world so as to increase the impact of TA. On the other hand communication is important for enabling the TA institute to keep in touch with the outside world and thus with reality. This class of methods includes (1) newsletter and focus magazines, perhaps including opinion articles (for creating awareness and pointing out critical issues); (2) science theatre and video presentations (to illustrate possible science and technology impacts on future society and everyday life); (3) websites, local questionnaires or debate forums (to facilitate or strengthen interactive communication at informal level); (4) networking and dialogue conferences (to promote mutual exchange and the distribution of the new ideas and issues to be considered).

3 NORMATIVITY AND VALUE ISSUES IN TA

It is no longer a point of controvery that technology development needs normative orientation because values and normative judgements enter into technological design (cf., for example, van de Poel [2001] and van Gorp [2005]) and technology development at many stages of the process thus determining the eventual societal implications of technology to a considerable extent. Normative judgements on technical options, technological impacts, or innovation potential with regard to societal desirability or acceptability are some of the many decisions which have to be made during technology development. Analysing such normative questions of technology and giving advice to society are some of the responsibilities of TA. However, the specific problems related to this type of advice must be carefully observed [Grunwald, 2003].

3.1 Normative judgements in TA practice

The prospective assessment of technological impacts is an important part of TA projects where normative and evaluative considerations play a role but not the only role. These considerations also accompany TA processes in the definition phase, in the implementation and in impact assessment:

Definition of the Task: TA topics do not arise "by themselves". Many questions on technology and automation could be asked in various ways, e.g., from economic or social, cultural or political, or even environmental or psychological perspectives. Stem-cell research can be addressed from the medical angle of curing Alzheimer's disease, or can be seen as a moral breach in the dike, gene therapy can be seen as a therapeutic instrument, or as a step towards a new form of eugenics, whatever the approach each uncovers completely different horizons of treatment and possible answers. The definition of the task is connected to a corresponding perception of the problem (e.g., with respect to the anticipated side effects). It is all bound up with priorities, perspectives, values, actors' interests and occasionally there might even be a desire to conceal certain questions. It is relevant to see who defines the problem, which people, groups and societal subsystems are involved, and what interests they pursue. Topic determination is the result of evaluation and it is, therefore, politically relevant. For that reason, the participation of those affected and of "stakeholders" in the definition, description, and structuring of the problem must be taken into consideration, more to the point it is even absolutely necessary in order to avoid coming up with answers which are completely irrelevant in social terms. At this point, tension occasionally arises between the scientific independence requirements of TA institutions [Grunwald, 2006b] and the topic determination dependency of clients, for example, parliaments [Vig and Paschen, 1999]. One of the responsibilities of TA is also to be critical of mainstream problem formulations and, in particular, to draw attention to aspects which have been neglected so far.

Delimitation of the System: Since it is impossible to completely investigate the entire spectrum of technological impacts or the consequences and implications of a technology, the contours of a concrete TA project must be determined in detail. Before beginning a TA study, one has to decide what is of cognitive interest and what can be left out. This concerns, on the one hand, converting the subject in hand into a series of detailed questions and, on the other hand, demarcating the limits of the system to be examined in spatial, temporal and thematic terms. Taking the example of life cycle assessment (LCA, Section 3.3.3), the significance of this delimitation can be immediately seen. Even for a simple technical product, the chain of preliminary products and processes can take on quite considerable proportions and this is even more so with complex products, such as a washing machine or an automobile. In view of the limits of temporal and financial resources, decisions have to be made as to how far one wants to retrace the manufacturing chain, and which processes or material flows can be rejected as irrelevant. When this sort of decision is made, disputes often arise concerning the matter of the extent to which these system demarcations prejudice the subsequent results. Decisions of this type are decisions on relevance and the importance of the problem in hand. In terms of method they are, therefore, evaluations. Thematic demarcations of knowledge interest have an effect on the choice of scientific disciplines, and possibly also of the societal groups that are invited to participate. This is how the areas of knowledge, ranges of values and interests taken into consideration are determined — and these, too, are normative decisions about what is relevant and what is not [Decker and Ladikas, 2004; cf. Section 2.6.1]. TA has to determine what interaction or aspects of the area of study are relevant to analysis and to finding a solution. This is done according to the normative evaluation criteria used to distinguish important aspects from unimportant aspects and is often controversial. What is important for one actor may be unimportant or even detrimental to others. There is a risk involved in making such relevance judgements: they could later turn out to be unjustified. It could transpire that despite all the care taken important aspects are "forgotten" or fail to be adequately assessed. This normative dimension in the initiating phase of TA projects and processes is precarious because it often crucially and irreversibly influences further stages.

Normative Aspects of the Methodical Approach: Certain TA project methods are not based exclusively on means-end rationality, that is to say, their likelihood of attaining the relevant aims pursued. Instead, normative considerations also come into play. By choosing quantitative methods, for example, one also accepts certain (normative) quantification rules. Although in many cases this may not be a problem, like in the quantitative recording of emissions by power plants, in other areas quantifications can be ethically questionable (Section 3.2.4). When choosing methods it is thus imperative to consider the relevant normative presuppositions. For example: are they adequate in that context, and accepted by those involved? This is analogous to scientific modelling which always involves normative preconceptions. For instance, in neoclassical economics we have the common concept of a *homo oeconomicus*, whose knowledge is comprehensive and who makes his decisions according to utility maximization. As soon as models are used in TA one therefore has to inquire into their normative assumptions, their adequacy, and their acceptability in the context in question.

Evaluation of the State of Knowledge: Comprehending and evaluating the level of knowledge on the technology in question as well as establishing its operating conditions and foreseeable consequences is an integral part of TA. This is no trivial matter involving the mere gathering of available knowledge but rather an activity with its own normative challenges. First of all, there is usually no consensus on the acknowledged "status of knowledge" regarding a certain issue. Because the knowledge required for TA is not generally textbook knowledge but rather knowledge that has to be sought at the cutting edge of research there is often no consensus within the relevant scientific communities. Instead scientific controversies tend to become the order of the day. These may consist of different estimations of the reliability of certain stocks of knowledge; they may also derive from divergent opinions on the significance of these stocks of knowledge within the context of the particular TA problem in question. The interdisciplinary nature of TA knowledge complicates these judgements. Knowledge assessment thus forms an independent step in TA processes [Pereira *et al.*, 2007]. The constituents of the "status of knowledge" which can be established as a consensus have to be determined and the scientific controversies have to be more closely investigated, both with regard to their epistemological and their normative origins. For this reason, the reflexive dimension of rationality [Decker and Grunwald, 2001] requires us, on the one hand, to reveal the uncertainties and controversies connected with the available knowledge. On the other hand, the difficulties that hinder the clear determination of the limits of knowledge in consensus have to be made transparent. TA includes, in this sense, epistemological considerations: the epistemological status of the stocks of knowledge used must be clear in order to preclude one-sided, exaggerated or arbitrary conclusions being drawn on the basis of knowledge which does not epistemologically support it.

Prospective Evaluation of the Impact of Technology: The evaluation of the possible consequences of a technology is in itself the most prominent and most often discussed point and the stage when TA problems of evaluation arise. This relates to challenges such as the assessment of risks, the appraisal of expectations concerning benefits and often the need to weigh up the facts. The following types of assessment situations are common in TA practice:

- The consequences of a technology can be judged in relation to the technologically, societally, or politically determined and legitimised *goals* pursued. Wherever there are politically determined objectives there is always a clear normative basis for evaluation (which can naturally be questioned on a different level). In numerous sustainability strategies there are, for example, political target values (e.g., with regard to CO_2 emissions) that can be used as evaluation criteria.

- The evaluation of the effects of technology can include a study of the attainment of goals from the *viewpoint of efficiency*. Are there other ways of achieving the same goals with fewer side effects, fewer risks and at lower costs, etc.?

- Such an evaluation can concern itself with the acceptance or acceptability of side effects. In this case, even the general rejection of a technology can be a topic, notwithstanding expectations surrounding possible benefits (as is often the case with genetically modified organisms). It could alternatively concern proposals for a moratorium or (as is more frequently the case) comparing the side effects that have to be accepted and the expected benefits.

In any case, TA's claim to transparency and comprehensibility makes it obligatory to disclose the respective assessment criteria (see Section 3.2.1). In that way citizens, politicians, or stakeholders can compare the premises of TA's conclusions with their own values and either accept (for well-founded reasons), modify or reject them. This increases the transparency of the public debate because positions are established and conclusions are drawn in relation to the underlying premises and values.

3.2 Methodological challenges

TA's methodological orientation aims to make it possible, even in the field of evaluations, to provide for the greatest possible amount of rationality, transparency and inter-subjectivity. The results of TA have to be protected from ideological suspicions and from being accused of being particularist or arbitrary. In this way specific methodological problems emerge, including the question of whether "objective" normative conclusions can be justified in the first place [Grunwald, 2003].

3.2.1 The origin of normative criteria

Normative criteria are required to evaluate all the fields mentioned above. These can be derived and justified in conceptually divergent ways:

- *Decisionism*: In the view governed by a strict "division of labour", the normativity needed for societally relevant decisions is created directly and immediately through the political system [Schmitt, 1934]. It is therefore superfluous to advise political bodies. Such possible advising has to limit itself to a representation of the factual situation and to the provision of descriptive knowledge. This position (cf. Section 2.4.1) will not be explored any further in the following sections because it is held to be obsolete for the reasons explained above.

- *Values Research*: With social-scientific methods, the values currently prevailing in society can be empirically investigated (for the risk case see Slovic [1993]). These empirical results can then be used by politicians or engineers as a normative basis for technologically relevant decisions to pursue technological design in accordance with citizens' values.
- *Participation*: Evaluative criteria can be negotiated directly with those affected. Through participative procedures (cf. Sections 2.4.2 and 3.3), citizens with their values, preferences and interests, can be directly involved in the constitution of the evaluation criteria [Joss and Belucci, 2002].
- *Philosophical Ethics*: Normative ethics attempts to derive the criteria for judging alternative technical options from universal principles by taking, for instance, the categorical imperative or the utility maximization rule [Ferré, 1995; Mitcham, 1994; Beauchamps, 2001].

Precisely which of these approaches to including normative considerations should be brought into play remains controversial (e.g., Grunwald [1999]). The question of where the evaluative criteria should come from and how it can be justified leads to fundamental controversy between the normative approach of philosophical ethics and the empirical approach of social scientific values research. While ethics warns against a "naturalistic fallacy" [Moore 1905] and rejects the idea that an "ought" can be derived from an empirically observed "is", values research investigates the values represented empirically in society and sets out to derive orientation from exactly those empirical observations.

In this field of tension participation can be employed in various ways: participative procedures can be "informed" by research into values and by philosophical ethics. Procedures can alternatively be understood to be the implementation of discourse ethics. Discourse ethics and deliberative democracy [Habermas, 1988b] have been taken as a model for participatory TA [Renn and Webler, 1998]. With such an approach, no substantial values about acceptable or unacceptable technologies are assumed to exist but the recourse to discourse ethics suggests the presence of normative criteria indicating how the participation procedures should be organised. It is, for example, required that the processes be fair and transparent, that the participants commit themselves to providing arguments instead of to merely trying to persuade their opponents and that they are willing to question and to modify their own positions if there are good counterarguments. In this way, discourse ethics can offer orientation on the organisation of a "good" and just participative procedure [Skorupinski and Ott, 2000].

At present, the relationship between the descriptive approaches of values research and the normative approaches of philosophical ethics are held to be predominantly complementary and cooperative by many TA practitioners as well as by many practitioners in Applied Ethics. Accordingly, there are TA problems where one can derive the evaluative criteria empirically and other TA problems where that is not possible. The question that then arises is: When, in TA, is there an explicit need for reflection and when is empirical research sufficient? The answer to this question obviously depends on one's understanding of ethics. Inasmuch as ethics is seen as a discipline that reflects on empirically existing moral conceptions and so relevant at the precise moment when conflicts arise between divergent moral conceptions [Grunwald, 2000], the decisive criterion becomes whether a moral conflict has to be dealt with or not in a given TA project. The following requirements have been proposed to operationalise this abstract criterion [Grunwald, 2005]: *pragmatic completeness* (the current normative framework has to cover all normative aspects of the decision to be made); *local consistency* (there must be a "sufficient" degree of consistency between the normative framework's elements); *non-ambiguity* (between the relevant actors there must be sufficient agreement on the interpretation of the normative framework); *acceptance* (the normative framework must be accepted by those affected as the basis for the decision); and *compliance* (the normative framework has to be complied with in practice).

If all these conditions are fulfilled there is neither moral conflict nor moral ambiguity and so there is no need for ethical reflection. The normative framework can be used by TA as a basis for normative evaluation without the need for further ethical reflection. In such situations, it is possible to carry out *virtually descriptive* TA, in which the normativity that has to be considered is not in itself an object of reflection but rather something that is gathered empirically from the prevailing political circumstances. This is especially true of standard design process situations [van Gorp, 2005]. It becomes problematic as soon as the scope of these criteria is transgressed. It is a serious challenge to TA to recognize this point at all. To do this, there must be corresponding "awareness" of and competence in making ethical judgements.

3.2.2 The possibility to generalise on evaluative judgements

In its advisory capacity to society and to politics TA operates in the public sphere and must work towards results that are valid beyond a subjective or particular level. The question is whether, to what extent, and under what circumstances assessments of technological impacts can be generalised. Can TA support judgements in a generalisable way, and in what methodologically secure manner can that be done? Can the evaluative aspects of TA just be left to societal negotiation processes and do they, therefore, depend on power differences? It is first of all indisputably true that TA cannot posit that normative postulates or societal values are valid, nor declare them to be binding. TA cannot, accordingly, substantially decide whether the development and use of a technology is acceptable, desirable or even imperative. TA can only concern itself *conditionally* with certain normative principles in order to propose methodologically secure conclusions on this basis.

It can propose "if-then" statements in the following syntax: "If one applies certain normative criteria, then this has the following consequences or implications for this technological issue ...". The "if" antecedents cannot be declared valid by TA: that is society's responsibility in its legitimized procedures and institutions, informed and orientated in a normative fashion through ethical deliberation and consultation [Grunwald, 2003].

It is this *conditionally normative* structure of evaluations that makes general and intersubjective statements on assessment problems possible. It makes it clear that evaluations are not simply a function of individual, subjective normative decisions but that there are in fact possibilities for scientific (generalised) evaluations. It is, thus, the task of TA to make this structure transparent and comprehensible. A political evaluation or decision is by no means anticipated or even obviated by this; it is still the responsibility of political or other societal opinion-forming and negotiating procedures to decide on the validity of the "if" clause. The "if-then" nexus must, however, be acknowledged as a scientific proposition that is accessible to scientific cognitive interest and to scientific method. In this manner, TA can contribute to not leaving the elaboration of the normative aspects of the evaluation basis to chance – in other words, to random constellations of actors or power relationships – but to rather improving the comprehensibility and transparency of societally relevant evaluations through systematic critical appraisal and through conditionally normative judgements [Grunwald, 2003].

3.2.3 Multidimensional integration

The choice of technical solutions usually depends on a number of criteria (cf., for example, Section 2.5.6). These criteria, such as risks, costs or environmental aspects, are generally rather heterogeneous and in part incommensurable (cf. Ibo van de Poel's chapter in this Handbook). Depending on the facts of the case, they carry varying weight when it comes to arriving at an overall evaluation and they can conflict. One particular challenge is, therefore, that of aggregating the evaluations according to specific criteria in order to provide a comprehensive evaluation that can form the basis of a decision. It is often impossible to achieve this by projecting the criteria onto a uniform quantitative scale (of, for instance, monetary values) in order to solve the problem by, for example, quantitatively maximising utility. In this way, conflicts on technology, problems of legitimisation and the inherent normative problems would merely be concealed in the underlying quantification procedures (Section 3.2.4).

TA studies on sustainability aspects are especially challenging [Ludwig, 1997]. They are carried out with the help of life cycle assessments (LCA; cf. Section 3.3.3) in all the pertinent dimensions of sustainability: ecologically, economically and socially. Over the course of a life cycle, for instance, in the extraction of raw materials, transportation, processing, use and disposal, a wealth of diverse and incommensurable aspects relevant to sustainability come into play. A sustainability assessment would have to provide a complete balance of these very heterogeneous factors. It would be an integration problem of considerable complexity. There is an extreme risk of providing arbitrary results in these multidimensional integrations, because methodologically secure integration is hardly possible in such a "jungle" of heterogeneous and possibly contradictory evaluations.

3.2.4 Limitations of quantitative methods

In many fields of science, quantification is the means chosen to make objective statements possible. Inasmuch as an acknowledged normative measurement theory and a correspondingly acknowledged quantification method exist "quantitative" can, under such conditions, be equated with "objective". In the social sciences similar hopes are to some extent founded on methods of empirical social research. In this area such expectations also lead to criticism and to allusions to the fact that only selective knowledge of societal phenomena can be gained through quantification. Reference is then made to the dimensions of meaning, communication and understanding, etc. that resist quantitative compilation.

Quantification is very popular among politicians and in public administration. These actors hope that quantification will enable the subjective questions of evaluation to be "objectivised". The availability of numerical values serving, for instance, as evaluative notches on a ranking scale not only facilitates a practical approach to problems of evaluation but it also suggests a kind of objectivity: the evaluation is reduced to a mathematical operation. Criticism arises when one queries the actual significance of these "objective" statements. These quantified evaluation procedures are only objective and adequate under the condition that the "measurement rules" and the method of calculation of the evaluative figures are acknowledged as methods by those involved.

In TA very diverse parameters are quantified. These include, on a level still very close to technology, the emissions of technical processes into various environmental areas (water, soil and air). In questions of evaluation, economic (monetary) quantifications of the expected benefits or detriment and, using the quantitative version of the risk concept, the probability of a possible adverse occurrence are some of the most frequently quantified dimensions. However, the degree of acceptance of or resistance to technologies in the population, or other representative survey results is also quantified, as are the results of Delphi-sample surveys.

There are limitations to quantitative analysis though like, for instance, when data is not available or quantifying measures are disputed. The latter is encountered particularly frequently, and not just in compilations and evaluations of the social and cultural consequences of technology. Even quantifications of the effects of technology on the natural environment, for example, in the form of monetary values for damaged natural capital are controversial because the utility of such *external effects* is not estimated by means of a market-like supply-and-demand mechanism but only through market simulations, for example by the "willingness to pay" approach. Examples of such problems are questions concerning the monetary value of a rare species of toad or of a songbird in comparison to the expected economic utility of building a road through their biotope. The value of subjective well-being or of an aesthetically pleasing landscape destroyed by the construction of an industrial park can also only be quantified with reservations, or not at all. A number of evaluation methods have been developed which, despite these problems, arrive at quantifications by using some dubious substitutive considerations. One of these is inquiry into the *willingness to pay* on the part of the persons affected. Those potentially affected are for instance asked in view of the possible loss of an aesthetically valuable landscape how much they would be willing to pay in order to preserve that landscape. On the basis of that method, the personal preferences of those concerned are transformed into monetary values.

Methods of this type are controversial when compared to the methods employed in physics or chemistry. Attributing a monetary or utilitarian value to an impact of technology (to a benefit or damage) is not free of political and ethical questions (cf. van de Poel, this Handbook). The basis of quantifications in theoretical measurements is inseparable from preferences, values, norms, and their changes over the course of time, and this is what differentiates all social domains, not only economics, from the domain of the natural sciences. In the social domain quantifications are dependent on the normative assumptions that enter into the method of quantification. This is why in the field of technological impact quantification remains controversial and does not just simply supply the expected "objective" facts of the case. This is especially drastic when, for example, in the economic modelling of the effects of climate change monetary values taken from calculations in the insurance business are assigned to human lives. A quantitative assessment of human life and of the quality of human life obviously meets with ethical objections.

These limitations do not render quantification obsolete in TA. In many cases, quantitative approaches are absolutely crucial to the development of assertions that will stand up to debate. In life cycle analysis (Section 3.3.3), quantification is conducted to assess the environmental impact of technology. This is vital to achieving an overall balance when faced with effects that to some extent compete. In appraising risk (Section 3.3.1), quantitative risk analysis is also often very helpful. Despite the problems already mentioned, the result of quantification is often beneficial but this does not mean that the results are acknowledged as objective by all parties. For example, the debate on the better environmental compatibility of non-returnable as opposed to returnable packaging cannot be decided on the basis of quantitative analysis: instead the dispute switches to how one could adequately quantify and how the limits of the system could be determined (Section 3.1.2). If the results of a quantitative evaluation in a technological conflict are not accepted by a given party, it is often not difficult to attack the quantification rules. The results of evaluations are dependent on the quantification methods chosen. For this reason, the normative aspects of quantification methods must be made transparent. Only then can the results of quantitative evaluations be interpreted appropriately and linked to qualitative content. Quantitative evaluations do not stand up "objectively" on their own. In TA they often depend on the manner of quantification. Therefore they must be integrated into a *transparent frame of interpretation and deliberation*.

3.3 Assessment methods

For reasons of inter-subjective comprehensibility and transparency, TA evaluation must be conducted in a methodologically well-substantiated way. In individual cases this can be achieved through chains of painstaking justification like, for example, with the argumentation for a certain interpretation of a system's limits under relevant conditions. However, when evaluating technological impact, there are scientific methods that have been developed for the further "objectivisation" of evaluation in the political and public spheres in which TA operates. In the following section some relevant methods are briefly presented in which the specific focus lies on the discussion of the normative aspects of these methods.

3.3.1 Risk assessment

One of the main reasons for the emergence of TA was because of the risks directly or indirectly caused by technology and its use. Any decisions made on technology are also simultaneously decisions about risks and they are, therefore, dependent on *ex ante* estimations of these risks and on a readiness to accept them. The mere fact that in the present we take decisions on future hazards and living conditions testifies to the considerable relevance of this subject while revealing its societal sensitivity. TA should and does contribute to the early signalling of risks and to how they should be dealt with (Section 2.3.2). In this respect, TA embraces elements of an "early warning" system.

Dealing with technological risks has always been a facet of the development of technology. In order to meet safety standards and, for instance, to obtain public licensing, some proof has to be submitted. Technical risk analysis and risk evaluation methods were therefore developed. When risk is interpreted as the product of the probability of damage (i.e., the probability of the occurrence of an accident) and the extent of damage (expressed as a rule in monetary units), the assumption is that risk can be quantified and thus "objectified". This procedure makes it possible to carry out risk-benefit analyses prior to decision making (cf. Hansson in this Handbook).

These traditional procedures of risk assessment have, however, two intrinsic limitations (cf. Hansson's chapter on risk in Part V of this Handbook and [Shrader-Frechette, 1991]). Firstly, for many new technology risk analyses quantitative experience is lacking which means that the extent of damage cannot be properly quantified. If quantifications are nonetheless given, it is easy to dismiss them as arbitrary, subjective or ideological. In controversial fields of technology, such as nuclear power or genetic engineering, the expected objectivisation of technological risks to be achieved on the basis of irrefutable practical knowledge have not succeeded. Secondly, especially in the discussion about the hazards of nuclear power, it has emerged that this "objective" concept of risk was useless in cases of crisis because the affected public was not very impressed by the "objective" numerical values. Although atomic energy, according to technical risk analysis criteria, did not seem to be problematic, society refused to accept it, notably because of the perceived risks. This was a reason for integrating the social-scientific and psychological approaches to risk into risk analysis while devoting attention to the phenomenon of risk communication [Slovic, 1993].

Philosophical ethics, by contrast, stresses the role of normative considerations in determining the acceptability of risks and formulated corresponding principles, such as the principle of pragmatic consistency [Gethmann and Mittelstraß, 1992]. According to this principle, the acceptability of technological risk is proportionate to the risks which someone voluntarily accepts when choosing a lifestyle (like, for example, that of engaging in risky sport). It is considered to be irrational to reject technological risks if they do not exceed the risks voluntarily accepted. This approach, however, fails on at least two grounds [Grunwald, 2005]: firstly, there is no objective and value-neutral way of comparing categorically different types of risk, for example risks of technologies that do not serve the same ends; secondly, the technologically induced risk would be additional to other risks so an extra step of agreed acceptance would be required in all cases (other philosophical approaches are analysed by Hansson in this handbook).

What is completely different is Hans Jonas' "imperative of responsibility" [1984] which advocates that the use of technology is to be avoided if it is conceivable that the perpetuation of humanity could be endangered by such technology ("priority of the negative prediction", "heuristics of fear"). In this case, the judgement does not depend on probabilities of occurrence. This type of radical judgement of technological risks and similarly radical demands for relinquishment or withdrawal has not gained general acceptance. Standpoints like Jonas' would, of necessity, lead to a complete standstill since one can, after all, imagine a catastrophe for practically every innovation. Arguments that give priority to negative prediction do not permit distinctions to be made between more and less risky undertakings.

In view of the lack of knowledge about possible risks and to avoid being confined to a "wait and see" strategy, with all the dangers of catastrophe which that brings (cf., for instance, the history of asbestos, Gee and Greenberg [2002]), the precautionary principle has been introduced to European environmental legislation. It has been incorporated in 1992 in the Treaty on the European Union. The precautionary principle establishes a rationale for political action in case of highly uncertain knowledge and it substantially lowers the (threshold) level for action of governments. The following characterisation of the precautionary principle shows – in spite of the fact that it still does not cover all relevant aspects – the complex inherent structure of the precautionary principle: "Where, following an assessment of available scientific information, there is reasonable concern for the possibility of adverse effects but scientific uncertainty persists, measures based on the precautionary principle may be adopted, pending further scientific information for a more comprehensive risk assessment, without having to wait until the reality and seriousness of those adverse effects become fully apparent" [Schomberg 2005, p.

168]. At present this discussion is particularly centred on the possible toxicity of nano particles. The implementation of the precautionary principle requires a careful evaluation of the state of scientific knowledge and of the gaps in that knowledge, as well as a political decision about the level of protection required against potential risks. TA is concerned with providing advice about political action with regard to precautionary and uncertain problems.

3.3.2 Cost-benefit analysis

The assessment of technology or of measures for dealing with the impact of technology with regard to economic efficiency is a standard TA evaluation (especially in Health Technology Assessment, HTA). This especially affects the cost-benefit ratio of major public projects or the evaluation of the efficiency of research stimulation programs. Cost-benefit analysis is a managerial evaluation procedure which is occasionally also employed in TA (cf. Ibo van de Poel's chapter in this Handbook for more detailed explanation). It attempts to quantify and balance all the pertinent decision data — the costs as well as the benefits — in monetary units. Although in this calculation, "external effects" such as risks to human health or to the environment can be taken into account, the corresponding damage must ultimately be expressed in terms of monetary units (cf. Section 3.2.4 for the problems).

Technological projects have to be appraised early on with regard to their expected economic efficiency. This not only applies to technical products such as automobiles or mobile telephones but also indirectly to questions, for example, of traffic infrastructure, building construction or to large-scale technical projects such as dam construction. Cost calculations for technological products have to be made over their entire life cycle. They consist of the *development costs* (expenditure for the planning stage, the potentially necessary research work, design, the drafting and conducting of tests and, if necessary, the construction of a prototype followed by production testing), the *manufacturing costs* (production costs in the form of expenses for materials, energy and labour or staff employment costs, construction or adaptation of production facilities, quality control, preparation of manuals), the *operating costs* (energy and material requirements at plant level, expenses for monitoring, day-to-day operational tests, maintenance, repairs) and the *waste disposal costs* (possibly also the reserves needed for specific risks, for disposal as well as for the final deposition of spent fuel rods; provision for the realisation of liabilities for the taking back of, for instance, old automobiles or electrical equipment).

3.3.3 Life cycle analysis and ecological balances

Sustainability assessment technology [Ludwig, 1997] is not restricted to the operating life of a technology but extends to include the entire life cycle, including the input chains and disposal. The sustainability effects of a technological product can only be comprehended by means of a life cycle assessment (LCA). When evaluating technological impacts on the environment, the LCA approach has long since been established. Ecological balancing indicators of the environmental compatibility of, for example, products or facilities make it possible to compare various alternatives and find optimum solutions according to environmental considerations. A process chain can highlight ecological weak points and pinpoint the priorities for necessary change. The norm DIN EN ISO 14040 "Eco-Management — Ecological Balance. Principles and General Requirements" has been formulated as a framework for carrying out eco-balances. Despite the numerous methodological difficulties, the field of environmental policy and the evaluation of environmentally relevant processes cannot be envisaged without ecological balance. A recent development is the idea of including economic and social aspects in sustainability evaluations.

An ecological balance consists of the definition of its objectives, a resource balance, an impact balance and an evaluation. The definition of objectives includes determining the scope and goals of the investigation. The resource balance includes drawing up a material use and energy balance for each of the system's individual processes, examining the processes with regard to meeting environmental standards and aggregating the resource balance for the entire product line. "Product line" should be understood to mean a representation of all the relevant processes in the life cycle from raw material depositing to waste disposal site. The inclusion of transportation processes and energy consumption details may also be important in this investigation; this is decisive in the dispute on whether non-returnable packaging materials are more environmentally compatible than returnable packaging materials. In the impact balance, the materials and energies consumed in the product line are determined in relation to environmental categories and are weighted accordingly. The result is then evaluated in relation to environmental compatibility.

Ecological balances do not make it possible to ascertain absolute environmental compatibility; they merely enable comparisons. Comparisons made using this method must relate to products with the same specific purpose. The results are presented as aggregated data, in other words, they say nothing about real environmental effects in specific places at a specific time but present instead total environmental impacts over the entire life cycle. If these results are to be accepted in decision making, the ecological balances must conform to the usual methodological requirements of comprehensibility, transparency and consistency. If results are questioned, it must be possible to trace them back to the input information, assumed functional dependencies or premises. Agreement must first be reached on these parameters — typical of methods in TA — particularly with regard to the system limits to be observed (Section 3.1.2).

3.3.4 Decision-analytical methods

Decision-analytical methods are oriented towards the problem of the multi-dimensional integration of various evaluative criteria (Section 3.2.3, cf. also Ibo van de Poel, in this handbook). They are based on the evaluation of options according to various, initially separate, evaluation criteria and on their subsequent weighting and aggregation leading to a comprehensive evaluation. First, the (socio-)technical options to be assessed have to be selected. The evaluation criteria according to which the options are to be assessed then have to be formulated. Sufficient knowledge of the characteristics and effects of the options concerned is required. These parameters include, for instance, risks, costs and the possible side effects but also the expected gain or loss of utility. These "impact dimensions" must be quantified in the form of utility values for each option according to the various evaluation criteria. Finally, weightings for the criteria chosen have to be agreed upon so that the aggregation of the respective utility values can be calculated to provide a total utility for each dimension. Assuming that all of the criteria are functionally independent of one another and not redundant the best possible option will be the one with the maximum amount of "total utility". The total utility is the sum of the separate utilities, added up for all of the n criteria. The separate utilities, in their turn, are the products of the individual utility values multiplied by the weighting for the respective criterion.

Within the scope of this *utility analysis* (or *scoring method*) there are a number of different procedures such as the *multi-criteria analysis* or the *multi-attributive analysis* with further method refinement, for instance, with regard to the compilation and processing of the data. By means of fuzzy logic, attempts are made to accentuate "soft" and differentiated evaluations. Furthermore, minimum requirements can be laid down for each evaluation criterion; failure to meet such minimum requirement would then disqualify the option concerned, even if it had done well according to other criteria. In this manner, the reciprocal substitutability of positive and negative part evaluations can be restricted. The influence of the individual contributions on utility and the influence of the weighting criteria can be tested by means of *sensitivity analyses* so that the robustness of the results can be examined.

When applying these methods, the results depend to a great extent on the original assumptions. Uncertainties and estimates necessarily replace well-founded knowledge. The results also depend to a great extent on the weightings: by varying the weighting they can be altered. The risk of ideological abuse is very high. In view of these considerations, the notion of calculating a "total utility" might be generally doubted (Ibo van de Poel, this handbook). The total utility is a highly aggregated construct which might be viewed as an artefact with almost arbitrary values depending mainly on the aggregation procedure. In view of these limitations utility analysis is not so much an approach to the algorithmic determination of an "optimum" problem solving option as an expedient for bringing about transparency in complex decision-making situations. It indicates the consequences entailed in assuming certain (positive or negative) utilities and weightings and is, therefore, of elucidatory as well as heuristic value.

3.3.5 Consensus conferences

Consensus conferences are among the best-known participative TA procedures (Section 2.4.2). They have their roots in approaches of deliberative democracy and were first employed in countries with highly developed cultures of discussion and standards of deliberation and discourse. The fundamental issue is to consider the prerequisites required by a functioning democracy in which highly specialised expert knowledge is essential especially in questions of science and technological policy: " ... prior to all decisions an open (free of domination) and informed debate by all concerned is required. This debate shall secure a possibility for all concerned to express their opinions and to be heard" [Klüver, 1995, p. 45]. To this end, "an informed debate" should be conducted "between the lay and the learned" (p. 46). This is done in the following way: "A consensus conference is a chaired public hearing with an audience from the public and with the active participation of 10 –15 lay people" [p. 47].

This type of meeting requires considerable preparation: the relevant questions are to be clarified beforehand and the experts and participants are to be chosen. Lay participants are sought through advertising in newspapers. A selection of those interested is made that roughly represents a cross-section of the population in terms of age, gender, and educational and occupational background. The sampling of the participants involves declared readiness to participate and selection according to criteria of representation. Random sampling is, to a great extent, excluded. Participants may not be experts or stakeholders. When preparing the consensus conference, great importance is attached to imparting factual and specialist knowledge to the participants.

The actual consensus conference takes three days. First there is "relay-running by the experts", then there is a "cross-examination of the experts" and finally, the "presentation of the final document" [Klüver, 1995, p. 49ff.]. The first step in the procedures serves to determine the acknowledged state of knowledge and to reveal divergences in the experts' opinions. In the second phase the aim is to reveal the reasons for these divergences through "cross-examination". At this stage, at the very latest, discussions will arise on normative presuppositions and implicit premises. This is the most important phase with regard to the guaranteeing of transparency.

In Denmark, where consensus conferences were developed, they are established by law. Consensus conferences have covered a vast number of topics like, for example, on the matter of genetically modified food products (cf. [Klüver, 1995] for an overview). Some of them have even reverberated in parliamentary decisions: in 1987, after a consensus conference on the subject, parliament decided to no longer use public funding to sponsor genetic experiments on animals. These consensus conferences acted as a model for the Swiss "PubliForum" approach, operated by TA-Swiss. Experiments with international consensus conferences have also now been carried out in a multilingual European setting. The recent and ambitious "Meeting of the Minds" project concerned itself with the challenges of neuro science (see http://www.meetingmindseurope.org/).

3.3.6 Citizens' juries and variations

In the "Citizens' Juries" method, lay people are required to judge a technological decision-making problem according to "common sense". The members of the jury act as an independent committee which pronounces a well-balanced recommendation committed to "public interest" after hearing expert witnesses, persons affected and the stakeholders. These approaches provide assessment and judgement involving independent citizens which serves as advice for decision-makers.

The "Planning Cell" can be seen as a specific type of citizens' jury. It was developed at the beginning of the 1970s and is, therefore, one of the earliest participative procedures. It is mainly employed in municipal decision-making processes, for instance, for urban and traffic planning. The basic idea is that 25 randomly chosen citizens make themselves so familiar with the problem in hand over a four-day period either collectively or in small groups that they can understand and judge the possible solutions. In order to attain a greater overview, a number of planning cells are organised to deal with the same problem. Their results are summarised in a citizens' expertise group. It is expected that in that way, socially acceptable and practicable recommendations will be acquired that are in the public interest. On the level of the individual participant, a strikingly high planning cell "event value" is acknowledged that is to say, the impression of being included in processes relevant to decision-making and of thereby being taken seriously as a citizen. On the societal level, a move towards more learning ability and towards a recapture of the role of the sovereign by the citizens is hoped for.

3.3.7 Mediation and arbitration

Mediation and arbitration are negotiation-orientated procedures designed to peacefully and consensually settle conflicts with the help of a neutral party (mediator, arbitrator). They usually derive from existing conflicts which the disagreeing parties are unable to resolve constructively without external help. The common interest of the parties in conflict is presupposed in a consensual and extrajudicial agreement. According to the "Harvard Model" [Fisher and Ury, 1988], it is assumed that the deadlocked positions can be loosened by revealing the parties' "real" interests before being transformed into "win-win" situations. Here, compensations agreed upon through negotiations play an important role.

Mediation procedures can also be employed preventively, in order to avoid matters escalating. Attempts are now frequently made to gather the potentially conflicting parties round a table in the preparatory phase of decisions on, for example, where to locate technical facilities, in order to effect understanding with the specific opponent before taking measures to de-escalate impending conflicts. In the end, it is a question of establishing a situation in which both sides have advantages or can partially realize their objectives.

The role of the mediator is to break down existing blockades in communication, initiate a process of settlement and supervise it. The conflict solution is not decided by the mediator but has to be discovered by the parties in conflict under the mediator's guidance. The requirements for a good moderator are: strict neutrality in the case in question, sufficient technical competence, a knowledge of the legal regulations and provisions, competence in dealing with groups and individuals, communicative skills and practical experience of moderating discourse, orientation to public interest and social respect. Since 1973, such procedures have been practised in different variants in the U.S. in relation to environmental issues and have to some extent become integrated into the law as an alternative to judicial conflict solutions.

In TA technological conflicts involving a limited number of actors and a precisely defined problem seem to be the appropriate fields for implementing mediation procedures. Such conflicts particularly revolve around location problems focused on the just and acceptable distribution of risks, damage, and the utility of large-scale industrial facilities such as airports, power plants, waste disposal sites, or chemical processing plants. Such NIMBY ("Not In My Back Yard") problems are, as a rule, local or regional and tend to be characterized by a specific planned event, by extreme intervention in the life and environment of the local residents or by a mixture of various interests.

3.3.8 Vision assessment

Quite often, as with the emergence of nanotechnology, visions and metaphors mark the revolutionary advance of science in general and act as an important factor in societal debates. Such visions have not yet been analysed comprehensively by TA. Preliminary analysis already has shown that futuristic visions are ambivalent: they may cause fascination as well as concern and fear. The main argument for requiring early vision assessment is the importance of visions in actual debates, that is, both in the debate on the opportunities afforded by scientific and technological progress and in ongoing risk debates. To provide for more rationality, reflexivity and transparency in these debates, vision assessment should also consider values [Grunwald, 2006a; 2007a].

Vision assessment is a new TA tool that is not directed at the assessment of technologies but at the assessment of visions which are communicated in the societal environment of technology [Grin and Grunwald, 2000]. The fields of nanotechnology and all the other converging technologies are currently being subjected to broad discussion [Grunwald, 2006a; 2007a]. Vision assessment can be analytically divided into vision *analysis* – which is itself subdivided into a *substantial* aspect (what is the content of the respective vision?) and a pragmatic aspect (how is it used in concrete communication?), vision *evaluation* (how could the content of the vision be evaluated and judged?), and vision *management* (how should the people and groups affected deal with the visions?).

Vision assessment includes normative elements, like the questions of how the cognitive aspects can be categorised, how they can be judged according to a degree of realisation or feasibility, according to plausibility and evidence [Pereira *et al.*, 2007], and what status the normative aspects have, for example, relative to established systems of values or to ethical standards. The general aim is to achieve a transparent disclosure of the relationship between knowledge and values, knowledge and the lack of it and the evaluation of these relationships and their implications. In particular, vision assessment should allow the various and, partly divergent normative aspects of visions of the future to directly confront each another. This can be achieved through ethical analysis and desk research. In addition, the stakeholders should discuss their differing judgements in workshops directly with each another in order to reveal their assumptions.

3.4 Normative backgrounds to assessment methods

The TA methods presented above differ in several respects: they are relevant at different stages in the TA processes, require different types of data, offer different types of knowledge, and (as will be discussed below) differ with respect to their normative premises.

The various TA methods (or families of methods) are usually applied in specific situations and in the context of specific TA approaches. Approaches such as participative TA or innovation-orientated TA adopt a specific view on technology, on society or on decision-making procedures:

- Cost-benefit analysis and MCDA are tied to the utilitarian decision-making calculus. They share essentials of utilitarianism like the reduction of different criteria to monetary values and the principle of maximising utility. This category also includes quantitative risk assessment aimed at minimising risk.

- Life cycle analysis (LCA) relies, in part, on ecological ideas about the environmental compatibility of industrial or other economic processes.

- Sustainability assessments bring the idea of (intergenerational and intragenerational) *justice* [Rawls, 1999] and *equity* into the arena of technological development [Grunwald and Kopfmüller 2006] .

- Types of participative TA, such as consensus conferences, usually work on the basis of normative ideas about deliberative democracy and discursive ethics [Habermas, 1988b; Renn and Webler, 1998], in which persons in positions of responsibility and interested citizens all share normative ideas, which are often very close to the ideas of civil society.

- Mediation approaches work with “checks and balances” and aim at mediating diverging interests, for example, by creating compensation strategies without giving priority to ethical principles.

Two essential points have to be recognised in each concrete TA process and in TA theory as well. First of all assessment methods are not, as has been shown, value free. Normative premises and presuppositions are usually involved in the selection of specific TA methods, whether directly or because the application of a certain method is often related to normative and conceptual assumptions. For example, there is a close relationship between cost–benefit analysis and the utilitarian decision-making calculus. In order to meet the goals of TA and to avoid biases it is, therefore, indispensable to apply a high degree of reflectivity with respect to such normative elements of TA methods and to establish a maximum degree of transparency in this regard.

Secondly, what can be learned from this analysis (and what has been supported by TA experience in the past decades) is modesty in terms of the expectation that TA should be able to reduce decisions about technologies and their societal environment to algorithm-like methodical procedures. In contrast to such expectations it has been shown that methods do involve normative aspects. By applying TA methods, various kinds of data can be collected, aggregated and evaluated for the purposes under consideration. Transparency can be strengthened and arguments can be supported by methodically guided research. But such activities cannot replace the very political and ethical nature of far-ranging technological decisions; they can only inform and orientate them. Decision-support systems — and TA may be seen as a specific kind of decision-support tool — they do not replace decisions but they rather *support* decision-making.

4 CURRENT DEVELOPMENTS AND FUTURE CHALLENGES

TA is context dependent with regard to the various topics, target groups, backgrounds, and fields of technology. Changes in context (the general societal and political setting, the roles and constellations of the relevant actors, processes of opinion formation and of decision-making) therefore have direct effects on TA's options for meeting its responsibilities. TA therefore has to observe the changes in its environment and react to them conceptually. In other words it has to actively reflect these changes in its own conceptual self-understanding. Current developments in societal, political and scientific contexts that are highly relevant to TA are:

Globalization: Until recently, TA's target group in technology, research, and innovation policies were primarily institutions within nationally or regionally orientated decision-making structures. Economic, but also political and technological globalization has changed this situation. The fact that the impacts of technology have no borders has long since been acknowledged. Globalization, however, also affects technological development, diffusion, and application. Technological design takes place today in worldwide networks. Examples are Open Source software and the Human Genome Project, or nano(bio)technology. The use and diffusion of technology is also becoming increasingly global. Electric power supply networks have long since grown beyond the political boundaries of national states. In the promotion as well as in the regulation of technology, important decisions are shifting to levels of higher aggregation, that is, from the national to the European level. The influence that regional "cultures" have on how technology is dealt with is decreasing, just as the leeway of the classical national states is shrinking. TA has to find ways of dealing – conceptually and methodically, but also strategically – with globalization and with new constellations. If it does not, it will be threatened by provincialisation and loss of importance. TA is challenged to organise itself internationally, to conduct the corresponding knowledge transfer, to contribute to the development and use of new governance structures and to set cultural and intercultural TA on the agenda. TA has to operate more actively than it has up until now on a supranational and, if required, a global level, and advise a correspondingly multilevel policy in the scope of a "global governance".

The Knowledge Society: The methods of production, the access to and the distribution of the means of utilising knowledge are affected by the development of a "knowledge society". Driven by the spread of information and communication technology, the importance of knowledge is growing in economic, social and political respects. Knowledge policy and knowledge management are becoming new societal domains [Stehr, 2004]. Actions and decisions will be increasingly substantiated and legitimised by scientific knowledge. At the same time, however, the founding of societal decisions on knowledge necessarily generates risks due to uncertainties of the knowledge, even to the potential self-endangerment of society. This exacerbates the situation of contingency in the *human condition* [Grunwald, 2007a].

Sustainable Development: The guiding principle of sustainability is that it demands a research and technology policy that fosters sustainability. For TA, this is significant in at least two respects: On the one hand much prospective knowledge on the consequences of new technological innovations for sustainability is needed, which (a) covers the entire life cycle of the technology and its components and (b) is not only ecological but also concerned with all of the dimensions of sustainability [Grunwald, 2007b]. On the other hand, this quite considerably increases the expectations placed on an "integrative" assessment of the impacts [Ludwig, 1997].

Backcasting approaches: In the last years backcasting approaches have regained importance, especially concerning sustainable development. For example, transformation management which currently is a frequently used notion, operates by defining desired futures and deriving measures and strategies which should be implemented today in order to reach the desired future states.

Foresight Exercises: there have been many (technology) foresight exercises in the past 15 years (for definitions of foresight cf. [Coates, 1985] and [Martin and Irvine 1989]). In particular the European Union has supported many such exercises, mainly in the field of regional foresight [FOREN, 2001]. Foresight activities have a lot of parallels with TA but are more explorative, emphasise the social effects (such as mobilising people in a regional or building network) and do not focus on normative assessment.

New Technologies: Changes and shifts of emphasis can be discerned in the characteristics of current scientific and technical innovations. It is no longer the traditional problems of large-scale facilities that is central but rather the development — as seen in nanotechnology and information and communication technology, all of which have culminated in the notion of "converging technologies" [Roco and Bainbridge, 2002] — leading to increasing integration and to the creation of ever more interfaces. As a result, decision-making processes are becoming increasingly complex. The future pace of technology is determined by the integration of developments from originally separated areas, rather than by individual innovations.

The Importance of Social Questions: The role of technology in society is less and less determined by the *technical* feasibility of products, processes or systems. Much that is technically feasible and that has also been realised and brought onto the market, is founded on societal embedding (as innovation research has shown), on economic aspects, on a lack of societal acceptance or on insufficient adaptation to existing technology (like with Transrapid, for example). Customer acceptance, or the lack of it, occasionally leads to unexpected turns — as, for instance, with the question of genetically modified food products in Great Britain, and currently with the question of whether and when UMTS mobile phones will be accepted on the market. Here, new interfaces between innovation research, the cultural sciences and TA are being opened up.

ELSI studies: In the last few years a new type of TA-related activity has emerged. ELSI or ELSA studies (ethical, legal and social implications/aspects) have been elaborated in some emerging fields of new technologies, mainly in the area of nanotechnology. Such activities are more selective in their scope than classical TA and they are often not directly aimed at decision makers but intend to broadly inform the interested public. In a methodological and normative sense, however, there are great similarities with established TA.

The Future of Human Nature: Converging technologies from the fields of nanotechnology, biotechnology, information technology and the cognitive sciences (NBIC, cf. Roco and Bainbridge [2002]) will enable humankind to improve human performance, at individual as well as at collective level. Emerging ethical questions [Habermas, 2001] as well as the potential for innovation and advance will be prominent topics for TA in the next years.

The history of TA can be recounted as a history of experimenting with concepts and of learning by testing or deducing from relevant conceptual debates. To date this might have been done rather sporadically and against the background of practical pressure. If that is so the time now seems to have come to take a look at the "whole" spectrum of TA and to develop a theory of TA which does not yet exist (tentative steps were taken in this direction in TATUP [2007]). A theory of TA can only be a theory of learning about TA and therefore a theory of reflection on TA *on the basis of its relationship to practice.*

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