

Means to an End Participatory Methods in Technology Assessment

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Abstract

This contribution builds on results from the EU-Project TAMI (Technology Assessment in Europe: Between Method and Impact). The general question to be answered in TAMI was "How can TA-institutions optimise the impact of their projects?". TAMI tackled this issue from two perspectives. The first one was straight forward: TA-practitioners must optimise their projects in order to increase their (?) impact. The second one took a more indirect approach by categorising the potential impacts of TA in order to identify concrete goals for TA-projects.

TAMI has developed a "from method to impact" structure which starts with an appraisal of the current social, political or ecological situation or problem and the definition of the concrete impact the TA-practitioner wants to aim for. According to both the current situation and the general stated goal, the TA-project will be designed to employ the combination of TA-methods that can be justified as the most promising one to reach this specific goal, while taking general TA criteria of good practice into account.

In this structure the means to an end aspect of TA-methods is obvious. The consideration of a certain method in the TA-project design can be justified referring to three aspects: 1. to the current situation, 2. to the impact to be reached, and/or 3. to general quality criteria of good practice in TA. This is true for participatory methods as well. Referring to the typology of impacts developed in TAMI, the relevance of public participation will be reflected upon referring to the PATH-conference topic "nanotechnology".

1. Introduction

Technology Assessment as problem oriented research is confronted with social and political problems which are rooted outside the area of science. Since problems in the real world are not classified according to usual academic disciplines one needs interdisciplinary or better transdisciplinary [Mittelstraß 2001; Gibbons et al. 1994] research to develop contributions to solve these problems. The effectiveness of the developed solutions also needs to be demonstrated outside science. This results in the fact that TA is a scientific endeavour which deals with science-external problems and wants to achieve science-external impact.

The EU-Project TAMI¹ (Technology Assessment in Europe: Between Method and Impact) was set up to answer the general question: "How can TA-institutions optimise the impact of TA?". TAMI tackled that issue from two perspectives. The first one was straight forward: TA-practitioners must optimise their TA-projects in order to increase the impact of TA. This has resulted in a "from method to impact" structure. The second one took a more indirect approach by categorising the potential impacts of TA in order to identify concrete goals for TA-projects. The main result is a typology of impacts TA can reach.

¹ The results of the TAMI-project are published in (Decker and Ladikas 2004) in which references for further reading are also available.

All TA institutions involved in TAMI² agreed on the following definition of Technology Assessment:

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 public and political opinion forming and not with 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 legitimate to solve these problems. Problem-solving is part of societal decision making processes that take place in established institutions such as national parliaments. There is a difference between advising and shaping: TA does not shape technology. Instead, it provides the knowledge for - and the advice to - the shaping of technology.

Secondly, science, interaction and communication are of crucial importance and form the three pillars of TA. Science provides knowledge about the consequences of technology, the conditions of implementation and the mechanisms for controlling technology development ("scientific methods"). Social relations to technology are characterized by issues 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 citizen participation. Communication is relevant for the distinction between "public" and "political" opinion forming. Obviously, "successful" communication in these fields has to meet different requirements. Therefore, communication is directly connected to "stay in touch" with the social surroundings. "Communicative methods" like newsletters, interactive websites, science theatres etc. are used to realize this. According to this definition of TA, participation is part of the "interaction" method-toolbox of TA, which makes the means to an end obvious. Participatory methods are used in order to reach a certain aim in a concrete (decision making) situation. In the following section the combination of different scientific, interactive and communicative TA-methods is described referring to an appraisal of the concrete problem at stake and to the identified aims. These aims, that correspond to potential impact TA can strive for, are categorized in an "Impact-Typology". The final section deals with the case of Nanotechnology and the current problems associated with it. On the basis of this problem appraisal methodology (?), the potential impacts TA could aim at in the future are discussed.

² Members of TAMI were: European Academy Bad Neuenahr-Ahrweiler, Germany; Parliamentary Office of Science and Technology, UK; Institute for Technology Assessment and System Analysis, Germany; Academy for Technology Assessment in Baden Württemberg, Germany; Danish Board of Technology, Denmark; Centre for Science and Technology Studies, Switzerland; Centre of Science, Technology and Society Studies, Czech Republic; Warsaw School of Economics, Institute of Modern Civilisation, Poland; Consejo Superior de Investigaciones Científicas, Spanish Policy Research on Innovation & Technology, Training and Education, Spain; Committee on Industry, External Trade, Research and Energy, European Parliament; Rathenau Institute, The Netherlands; and, Flemish Institute for Technology Assessment, Flemish Parliament, Belgium.

2. From Method to Impact

2.1. Situation appraisal

According to the problem oriented approach the TA-practitioner starts with a detailed appraisal of the current political, social, ecological situation or problem. This situation appraisal refers to the following dimensions:

- **issue dimension**
The first – and trivial – dimension is the issue a problem is related to. When appreciating the situation, it is important to be aware of the way the issue is framed. It might be a *technology oriented* issue, i.e. the problem is connected to a concrete technology like, for example, transportation systems, waste-treating technologies, energy supply techniques or concrete treatments in bio-medicine. Since technology intervenes in many domains of our life, like health, work, entertainment, mobility, etc., it might be sensible to frame a problem as a *domain oriented* issue. Classical examples are e-commerce or e-health. Finally, the *consequence oriented* approach might be the most adequate. 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.
- **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 the agenda setting phase government has not yet officially addressed an issue. In the policy making phase an issue is already on the political agenda, and at the stage where fundamental decisions have to be taken. The policy implementation phase represents the stage of the policy cycle, in which a clear policy on the issue at stake (e.g. fostering e-learning) has been decided, but the policy has still to be implemented. Finally, the political problem might be 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.
- **social dimension**
Another characteristic aspect is the social dimension of the issue under consideration. 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 reaching the relevance of values in a concrete case and situation is. The *relation to the public* is of crucial relevance. Is the issue already raising public interest? How is the interest expressed if it exists? Is there fascination, rejection, mistrust? Who is leading the social discussion? Are large organisations (parties, churches, social movements) aware of the issue? *Social roles and relationships* must be considered. The design of a TA study may decisively depend on the assessment of the roles of experts, decision-makers and laypersons and their mutual relationships in the respective field.
- **innovation dimension**
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 being different stakeholders and social groups 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 situation appreciation. Following the widely used model of the innovation chain, we were able to identify the following different devel-

opment stages research and development in the early stages, industrial research, the marketplace, widespread diffusion, and embedded technological systems.

- availability of knowledge
TA has to provide knowledge and to perform knowledge management. Knowledge generation in TA has 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 belongs 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 in knowledge ("gewusstes Nichtwissen" "acknowledged ignorance").

2.2. Impact-Typology

According to the problem situation at stake the goal to be reached by the TA-project needs to be defined. It was one of the tasks of the TAMI-project to think about potential impacts TA can have. The following Typology of Impacts shows different types of impacts TA can strive for. From the perspective of TA-practitioners these potential impacts can be read as potential aims to be reached with a concrete TA-project.

Table 1 - 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 of 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 of 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

One could roughly discern three dimensions of impact that TA or policy consulting in general could have: impact in the dimension of knowledge used in policy making or public debate, impact in the sense of forming opinions/attitudes of actors in-

volved in the debate, and impact in the sense of initialising actions taken by policy makers or other actors.

These dimensions of impact can be related to three dimensions of the issue that TA-projects usually deal with and that TA is expected to generate knowledge about. TA has to deliver (as comprehensive 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/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 basis of a proper description of the scientific and technological aspects, in connection with a description of the social environment (debate, actors), TA has to analyse the *policy aspects* of the problem, meaning it has to consider the restrictions and opportunities of policy making and has to develop policy options, i.e. explore politically viable ways for problem solving (e.g. legislation, R&D funding, action plans) and again evaluate options with regard to possible side-effects (e.g. social conflicts) they might have.

Using these dimensions of impact and dimensions of the issue we gain a matrix that shows nine types of impact of Technology Assessment. An inventory of 23 roles or functions of TA that was developed by the members of TAMI-project can be categorised according to these types of impact.

1. Raising Knowledge

The three types of impact in the column "raising knowledge" are perhaps most directly related 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) may make policy makers or other relevant actors aware of formerly unknown scientific knowledge on risks, chances, unintended consequences etc. (scientific assessment), of interests or perspectives of actors involved (social mapping) or of problems or options for policy making (policy analysis).

2. Forming Attitudes/Opinions

Raising knowledge (by output or process) is a precondition for starting learning that might aid the formation of opinions and attitudes amongst actors. Changes in attitude may occur with regards to new scientific aspects that are discussed among policy makers or in public debates (agenda setting). The TA-process or outcome might also change the way relevant actors see or deal with each other (mediation), or options for policy making might be seen/discussed in a different way, e.g. new options becoming prominent on the agenda of policy making (restructuring the policy debate).

3. Initialising Action

Impact in the dimension of "initialising action" means that a TA process influences directly the outcome of the policy making process. Regarding the scientific aspects of the issue at stake, a TA-process may lead to reframing of the debate, e.g. initiatives to further scrutinise aspects of the problem. With regard to the societal aspects (actors, conflicts) policy makers may decide to initialise new ways of decision making, e.g. to set up a programme to intensify public discourse or to include social groups in the decision-making process. Apart from such initiatives, which can be seen as new ways of dealing with the problem, it might also be that TA leads to a definite decision about new policies (in the sense of closure of the debate): e.g. to implement a technology, or to set up legal rules for implementation.

The three dimensions given above might also be read as an “effect-continuum” starting from “raising knowledge” and leading to “forming attitudes/opinions” and, eventually, to “initialising action/initiative”. In the first dimension one could speak of a low level of effect (i.e. a client notices the results of a TA process) which may imply a “fuller understanding of the problem” or “a broader view of aspects related to the problem” without directly inducing a change in attitude or behaviour. This is the necessary first step to a more explicit effect in the dimension of “attitude” and “action”: the application of new knowledge stemming from TA studies becomes visible, knowledge is observably applied as argument in the debate and this might have direct impact on decision making in the sense of changing its path and/or bringing up new political initiatives. The latter two steps obviously imply not only awareness but also application of knowledge in a narrower sense and therefore presume an active adoption of knowledge where it has to be integrated into the “belief system” of actors. The application of knowledge in political action is naturally also highly dependent on constraints and opportunities given by the actual policy context (e.g. need for compromises in policy networks, respect for existing policy coalitions, compatibility with existing policy programmes etc.).

2.3. The Method-Toolbox

The general idea behind the “From Method to Impact”-structure developed in TAMI is that the most promising design of a TA-project, i.e. a specific combination of TA-methods, can be justified referring to three aspects: 1. to the current situation, 2. to the impact to be reached, and/or 3. to general quality criteria of good practice in TA. This perspective stresses the means to an end character of TA-methods. According to the definition of TA mentioned in the introduction three categories of TA-methods can be identified:

– Scientific methods

Scientific methods are developed in disciplines of natural or social sciences applied to TA problems, in order to collect data, to allow prediction, to make quantitative risk assessments, to allow for the identification of economic consequences, to investigate social values or acceptance problems, to enable for eco-balancing. This class of methods includes:

- Delphi method, expert interviews (for collecting expert knowledge),
- Expert discussion
- Modelling, simulation, systems analysis, risk analysis, material flow analysis (for understanding the socio-technical system to be investigated)
- Trend extrapolation, simulation, scenario technique (for creating knowledge to think about the future)
- Discourse analysis, value research, ethics, value tree analysis (for evaluating and uncovering the argumentative landscape)
- etc.

– Interactive methods

Interactive, participatory or dialogue methods are developed to organise social interaction in order to make conflict management easier, to allow for conflict resolution, to bring together scientific expertise and citizens, to involve stakeholders in decision-making processes, to mobilise citizens for shaping society’s future, etc. This class of methods includes:

- Consensus conference
- Expert hearing
- Focus group

- Citizens jury
- Future search conference
- Scenario workshop
- Perspective workshop
- Etc.

– Communication methods

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 product to the outside world in order to increase the impact of TA. On the other hand communication is an important feature for the TA-institute to keep in touch with the outside world and to keep track with reality. This class of methods includes:

- Newsletter and focus magazine
- Opinion article
- Science theatre
- Video presentation
- (Interactive) websites (e.g. local questionnaire, debate forum, video, ...)
- Networking
- Accompanying
- Dialogue conferences
- Etc

2.4. General Quality Criteria

Moreover, the selection of the methods is influenced by the fact that TA-Institutions want to realize high quality projects. The quality criteria to be considered can be structured along the structure of the method toolbox:

1. 1. Scientific quality criteria are revolving about the interdisciplinary nature of TA-topics (since only in rare cases one individual scientific discipline is able to solve a problem in a comprehensive manner). This means first of all that high level disciplinary contributions have to be realized, as they are necessary conditions for high quality interdisciplinarity. Moreover, the combination of the disciplinary perspectives to a comprehensive interdisciplinary argumentation is of crucial importance. This includes the explanation of underlying assumptions and the determination of a project relevant framework. Finally, one has to ensure that the relevant cross-correlations between the different scientific disciplines are re-alized. Did they ask the right questions crossing the disciplinary boarders? Since these aspects of interdisciplinary science are obviously not self-explaining, additional measures ensure the scientific reliability (like peer reviews) are of crucial importance.
2. Interactive quality criteria are mainly connected with social and procedural fairness. The first considers the selection of the institutions or persons, who will contribute to the project, i.e. interact with each other. The latter takes into account the way the interaction is organised. One has to meet dialog standards, democratic decision procedures, etc. Moreover one has to reach for a transparent process, i.e. for example transparency about interests and values and a transparent argumentation and documentation.
3. Regarding communication quality criteria, flexibility is necessary during the project implementation and dissemination phases as the original situation apprecia-

tion might change. Such changes might concern the political agenda (e.g. a law is postponed or advanced), the public debate (e.g. a "scandal" raises interest for an issue, an issue has a "media peak" for a few weeks) or the scientific community (e.g. new findings). Moreover the diffusion of the results is of crucial importance. A communication strategy with all kinds of media has to be developed including informal and continuous communication based on attractive and easy accessible communication tools. Here, also a striving for synergies might be sensible, since collaboration with science museums or radio or TV stations allow for multiplier effects.

2.5. Selection of the TA-methods: The Project Design

After the situation appraisal and the goal setting the development of a TA-design starts. As highlighted above, it is composed out of different methods. The main criterion for the method composition process is the development of a TA-design, which can be justified as the one with the highest potential for reaching the identified aims. However, in addition to this main criterion, more general aspects concerning "best practices" in TA will also be taken into consideration. Therefore the selection of the relevant methods to develop a concrete TA-approach is based on both the justification for reaching the goal and the necessary condition to reach high quality TA-results. Here also, the need to keep pace with the evolving societal, political and scientific situation has to be taken into consideration.

Justifying the selection of the relevant methods is done by referring to the goal setting after the situation appreciation. In the case of a project aimed at creating knowledge, one could start with identifying the relevant scientific disciplines, selecting the experts out of these disciplines, organising and moderating the expert communication process, etc. Another option would be to establish where knowledge is needed and launch an interdisciplinary study aimed at collecting knowledge via bibliography research, interviews, etc. If the situation appreciation shows that the different involved actors are in conflict or a deadlock, one would start with identifying possible stakeholders, perhaps identifying citizens concerned by the new technology under scrutiny, organising and moderating the communication process, selecting ways how the scientific knowledge is transferred into the discussion process, etc.

Referring to the three categories of methods in the so-called "method tool box", it has to be underlined that there is no need to systematically combine methods out of the three categories, in order to design a "complete" project. "Complete" is here understood in the sense of "most promising", after the situation appraisal and the following goal setting: for example, there may be cases in which pure scientific inquiry or an individual newspaper article are the most effective; It is not necessary either to restrict the choice to only one type of method within each category: an expert hearing followed by a citizens jury or a Delphi process combined with an expert discussion might indeed be identified as the most promising project design in some cases. Moreover, as mentioned above, the project design is developed referring to general quality criteria as well.

3. The case of Nanotechnology

Nanotechnology (NT) is among the most prominent emerging technologies, heralded as a key technology for the 21st century. These - potential - innovations offer numerous benefits. There are great expectations among policymakers, scientists and industry representatives that nanotechnology may - or will - contribute to economic prosperity and sustainable development (for an up-to-date and comprehensive overview see (Paschen et al. 2004). On the other hand, nanotechnology has been the subject of an extensive public debate in Europe and the United States. Especially the risks of NT – from the suspected asbestos-like properties of some

nanoscopic materials and the resulting dangers for human health to the potential threat by self-replicating nanobots turning the entire world into 'grey goo' – got broad media coverage and public awareness. Obviously, nanotechnology is a case for technology assessment.

3.1. Lack of a general definition

Technology Assessment of nanotechnology has to deal with several methodological challenges: First of all, it is still quite blurred what in detail should be considered as 'nanotechnology' – and what should not. Until now, there is no definition of NT that is generally accepted in the scientific community. Perhaps such a definition is impossible at all. The 'definitions' proposed – and used (?) – by research policy or its think tanks and consultants are rather broad and unspecific, and they leave lots of room for interpretation. There have been several attempts to transfer these descriptions into an operational definition, the most elaborate and stringent one being the one developed by an expert working group co-ordinated by the Europäische Akademie zur Erforschung von Folgen wissenschaftlich-technischer Entwicklungen Bad Neuenahr-Ahrweiler (European Academy for the study of the consequences of scientific and technological advance) (Schmidt et al. 2003): "Nanotechnology is dealing with functional systems based on the use of sub-units with specific size-dependent properties of the individual sub-units or of a system of those. ... Functional systems are systems where the (technological or natural) functionality to be considered provides the criteria for defining system boundaries. ... The specific-size dependence of these properties becomes evident when they a) no longer follow classical physical laws but rather are described by quantum-mechanical ones; b) are dominated by particular interface effects; c) exhibit properties due to a limited number of constituents, since the usual term 'material' refers to an almost infinite number of constituents (e.g. atoms, molecules) displaying an averaged statistical behaviour."

Surprisingly, this definition does not refer to a particular part of the length scale where nanotechnology is usually expected to be 'at home'. Common 'definitions' traditionally limit nanotechnology to structures with a size somewhere between 0.1 nm and 100 nm in at least one dimension. The authors of the above definition consider this interval 'as a good approximation', but not as a 'plausible measure to define Nanotechnology' because one can find structures within this interval that do not show these 'specific size-dependent properties' which on the other hand can occur also in structures with sizes above 100 nm (or even 1000 nm). They propose that the name-giving order of magnitude of nanotechnology should not be mentioned in the definition, because this would imply exclusion rules independent from a scientific evaluation of the fundamental working principles of a functional system described by three criteria.

According to this definition (but also interpreting other widely-used descriptions of the field), nanotechnology is neither a specific technology nor it is a definite group of technologies. Nanotechnology comprises a wide range of approaches that are quite heterogeneous with regard to their subjects of investigation, possible applications and imaginable periods of realisation. Many of the developments called 'nanotechnology' are scientific findings and curiosities rather than R&D results close to a technological application. Very often, even the engineering and economic feasibility has not yet been clarified.

3.2. NT is an enabling technology

Some nanotechnologies are so-called 'enabling technologies' (Fleischer et al. 2005). They are – often crucial – technological prerequisites for other technologies, products and processes which are expected to impact existing technologies by expanding their usefulness, to enable new technological approaches and to trigger wider

applications in a number of industries. Enabling technologies often have no direct – i.e. easily recognisable – connection with applications which makes it difficult to even determine relevant impact categories. Therefore it is necessary to perform intermediate analysis steps to connect these technologies to applications or visions for their integration in application technologies or products. Such a connection is a sufficient basis for a scientifically sound, knowledge-based TA considering societal impacts before they are widely implemented, i.e. at early stages of their development, when the direction of the innovation process can still be influenced. Yet, most questions about the relevant consequences and options to influence it arise in the later phases of the innovation process, from the diffusion to the market, the use of technology and its disposal. This holds considerable methodological challenges with respect to analysis and assessment for all emerging technologies, but especially for emerging enabling technologies.

3.3. Toxicological risks

Nanoparticles are already used in several products. Sunscreens and tyres of cars are examples. With the help of nanoparticles it is possible to optimise different material properties like for example adhesion and attrition of tyres. However, the toxicological impacts of nanoparticles are still unknown. This might result in the distribution of nanoparticles in the environment and in the associated exposure of living organisms. Concerning production processes an increase is expected within the next years, which might result in increased (?) direct exposure of humans at working places. With regard to such an exposure the ultrafine particles will play the most important role, because they reach the deep lung and are possibly inducing diseases. The state of the art is described in Brune et al. (2006):

“Besides some first evidences for biological or medical relevant effects within organisms, there exist only a small number of studies that demonstrate possible negative effects on living organisms or the environment, on the basis of which risk characterization could be achieved.”

On the basis of this statement, the authors state that the precautionary principle requires that the nanoparticles are handled very careful. One needs longterm monitoring activities and a continuous and comprehensive process of analysis and assessment of the knowledge available.

4. Conclusions

If one uses the Impact-Typology developed in TAMI in order to identify potential goals of a TA-project in the case of nanotechnology, one can assume that most goals are in the area of the upper left corner “Scientific Assessment”. It is about raising knowledge about scientific and technological aspects of nanotechnology. In the case of the toxicity of nanoparticles the toxicologists have just taken off to investigate the behaviour of nanoparticles. Since one cannot assume that nano-size particles show the same behaviour than bulk material and does not know at which size the behaviour might change, it is necessary to investigate several particle sizes of the same material in order to get a comprehensive assessment of its toxicity. Having a database of the toxicological effects of nanoparticles (as for example proposed in nanocare, <http://www.nanopartikel.info>) would be a kind of “comprehensive overview of the toxicological consequences” of nanoparticles. This is, in accordance with TAMI findings, a purely scientific assessment.

Taking the enabling character of nanotechnology seriously, i.e. that the same nano-effect can be used in different products, the need to perform an intermediate analysis step to connect the nano-effect to concrete applications or visions for their integration in application technologies or products has already been identified. Developing a science and technology roadmap would constitute such an intermediate step

(Fleischer et al.2005). Again, raising knowledge about the path from science to concrete technological application is a scientific methodological issue, and therefore part of the scientific assessment within TA (upper left corner of the impact matrix). After the identification of a promising path to a concrete project one can start a "usual" TA-project for technologies in early development stages.

These examples show that in the case of nanotechnology, participatory methods are not the most promising means to reach the identified ends. Most pressing "problems" of TA of nanotechnology need a scientific assessment in order to gain the knowledge for further steps.

Yet, this approach is not relevant for the identification of an acceptable risk level modern societies would like to establish for dealing with nanoparticles. Since there is already scientific evidence of a toxicological impact of nanoparticles and given that we do not know enough about the cause and effect relations, we are in a situation in which the "precautionary principle" comes into play (COM 2000, Schomberg 2005, Brune et al.). Here, the negotiation about the "protection level" as well as the identification of the acceptable security level is an end which can be reached by participatory means.

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