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Techno-visionary Sciences

Challenges to Policy Advice

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Abstract

Scientific policy advice on issues of science and technology looks back to a tradition of more than 50 years. Technology assessment (TA) has been developed since the 1960s, frequently in relation to or on behalf of political institutions such as parliaments and governments. In general, science and technology studies (STS) appear to be (or, at least, to have been until quite recently) more academic and more distant to institutionalised political decision processes in a strict sense (the 'political system').

Seen against this background, one main thesis of this paper is that the rise of new techno-visionary sciences, such as nanotechnology, significantly contributed to a process of convergence between STS and TA. The reason for this can be located in the particular relevance and virulence of the 'Collingridge dilemma' for these sciences. Due to the high uncertainties with respect to the knowledge about impacts of the related technologies, TA has to look for other than empirical or logical arguments to support 'upstream' technology impact analyses – and can find them partially in theory-based work in STS, for example in the context of the debate on the co-evolution of technology and society. STS practitioners, in turn, see options and the need for 'going public' in a new way (and at an early stage of development), now increasingly including the institutionalised political domain. Equipped with their refined analytic, interpretative and ethnographic capacities, STS are moving further into often unfamiliar policy terrain which has its own logic and distinct set of rules.

The paper analyses and reflects on ongoing shifts in the 'landscape' of scientific policy advice, focusing on the rise of techno-visionary sciences and converging technologies. Another aim of the paper is to orientate STS and TA toward mutual learning processes and intensified cooperation, based on existing experience in both fields.

1 Policy advice and the governance of science

The governance of science in society has become an important issue in the past decades. Reflexivity has increased in the sense that appreciation of as well as concerns about the roles and impacts of science in society have prompted calls for new elements in the governance of science (Markus/Siune, et al. 2009). Ongoing changes in the governance of science are indicated by the move to enhance democracy by including more stakeholders and bottom-up deliberative processes in science issues, the emergence of upstream analysis and engagement in important fields such as the nanosciences, and the advancement of notions such as 'responsible development' and 'responsible innovation'.

Overall, this subjects the governance of science and the shaping of technology to far more complex requirements than those imposed by earlier ideas. Governance of science nowadays is regarded as a phenomenon that is determined by multiple factors and involves citizens, scientists, research organisations, academic institutions, political actors, agencies, non-governmental organisations and authorities. It is thus clear that policy advice must adapt to this increasing complexity as has been explained by Markus/Siune, et al. (2009). This paper's point of departure is the observation that the emergence of techno-visionary sciences further increases the complexity of science and technology governance.

Scientific policy advice on science and technology issues has been provided for more than 50 years now. Many concepts have been proposed, developed and, in some cases, put into practice. 'Technology assessment', one of the more prominent approaches, has been developed since the 1960s, frequently in close cooperation with political institutions such as parliaments and governments (Bimber 1996; Vig/Paschen 1999; Grunwald 2009a). Applied ethics have expanded advisory activities in the past decade, mainly in the field of life sciences and medicine, and have recently also focused on new and emerging science and technology (Rip/Swierstra 2007). The issue of anticipatory governance and the concept of real-time technology assessment (Guston/Sarewitz 2002) have emerged at the borderline between technology assessment (TA) and 'science, technology and society studies' (STS) which over the past decades have developed in more or less separate ways. Although these approaches share some similarities, there are also differences, one of them concerning the role of self-perception: do they view themselves as distant observers or as part of the game aimed at intervention? The "classical" view of STS and the sociology of science has been characterised as follows: "The sociology of science is often accused of sitting on an epistemological fence (…). Although fence-sitting is still an honourable epistemic tradition, many in the field today enjoy camping out, not on fences, but on ‚boundaries'." (Webster 2007, p. 458)

This view is inherently ambivalent: it values "fence-sitting" as an "honourable tradition" because the observation of social issues in research often requires a detached observer. However, there is also a sense that this position, despite being necessary, may not be sufficient to satisfy current expectations. STS should thus go beyond fence-sitting and show more practical engagement: "The STS analyst can (and does) play an enabling role in such initiatives [projects that are designed to develop new forms of public inclusivity]. My argument is that the three entry points [the characterization and anticipation of emerging techno-science fields; the exploitation of (future) technoscience; the context in which technoscience applications are used] bring our focus down from the meta level to more meso and tractable forms of engagement and critique *within the policy room itself*." (Webster 2007, p. 472)

Technology assessment has arrived at a clear conclusion concerning its own position in this debate, as is also demanded by many research programmes: TA is to have impact and must therefore "make a difference" – and that means that TA admits to taking responsibility for intervening in ongoing decision-making processes (Decker/Ladikas 2004). TA has considerable experience in the field of advising political institutions such as parliaments with and without public participation, allowing the conclusion in many cases that TA really "made a difference" – and in other cases did not. Recent notions have been developed such as responsible innovation and responsible development[1], as well as interlinked and systemic models of R&D, of innovation and of innovation systems. These offer societal actors and groups – especially civil society organisations (CSOs), some of which have already contributed considerably to debates on emerging fields of technology such as nanotechnology and synthetic biology – opportunities to influence R&D and innovation processes. In such a world, 'responsible development' is not a symbolic reference, but can be made operational (Markus/Si une, et al. 2009).

In this paper I will address the emerging implications and consequences of the expanding field of techno-visionary sciences and the related debates (see Sec. 2) on scientific policy advice and ask for new approaches, concepts and methods of policy advice. The use of envisaged possible futures such as scenarios to achieve orientation has been established since the 1950s, first of all in the military domain. However, the use of such futures has changed over time, particularly with regard to emerging techno-visionary sciences. In this context, I will elaborate on the following hypotheses:

1. Scientific, public and political communication about techno-visionary sciences may frequently have a *genuine impact* on society – on public attitudes, perceptions of policy-makers and funding policies – irrespective of their degree of plausibility, feasibility and speculativity. Even highly fictional debates may also receive real power (Sec. 2).
2. Policy advice is thus also needed in these fields but faces not only the great lack of knowledge but also the hope and hype structure of visionary debates. Policy advice can therefore no longer be expected merely to give concrete information about the consequences of technology but to undertake more hermeneutic and reconstructive work on the content of the visionary futures; the very nature of these visions must be made transparent in terms of epistemic, normative and strategic issues (Sec. 3).

Meeting these challenges requires (a) more knowledge about the dissemination of visionary futures and the mechanisms by which they influence public debate and policy-making and (b) new assessment and reconstruction procedures concerning visionary futures (Sec. 4).

This paper has a programmatic and conceptual focus. It does not aim to present empirical data. On the basis of a sound diagnosis of the increasing role of techno-visionary sciences in public and policy debates about science, conclusions are drawn in order to identify further research needs and practical challenges in scientific policy advice. New assessment approaches will be tentatively presented – not as ready-made answers to the challenges identified, however, but as proposals

[1] Examples are the Dutch funding agency NWO's programme on *Maatschappelijk Verantwoord Innoveren* (www.nwo.nl/mvi), and the Norwegian Research Council's programme on Ethical, Legal and Social Aspects of New Technologies (www.forskningsradet.no).

and ideas for future research in this field.

In this context I can draw on some practical experience gained in recent years which indicates that policy makers are aware of the "real power" of techno-visionary communication and are seeking policy advice in the areas involved. For example, a chapter about techno-visionary communication on human enhancement, "converging technologies" (nano-bio-info-cogno convergence) and other far-reaching goals, compiled by the Office of Technology Assessment at the German Bundestag (TAB) as part of a comprehensive TA study on nanotechnology (Paschen et al. 2004), was very well received by the German Bundestag. By "isolating" the futuristic visions in a separate chapter, TAB performed a kind of 'boundary work' (Gieryn 1984) even at the study's design stage, yet at the same time giving plenty of room to these visions (cf. Simakova and Coenen 2013). The authors of the TAB study came to the conclusion that this techno-visionary discourse played an important and to some extent new role in the governance of science and technology (new at least in civilian research and development), while also entailing new challenges for TA. As regards techno-visionary communication, all political parties in parliament tended to be more enthusiastic about nanotechnology than the TA study was; nonetheless, just like other political institutions, they often also warned against futurism in much the same vein as the TAB, thereby contributing to the German variant of the boundary work on nanofuturism which in the US culminated in the Drexler-Smalley debate (Selin 2007).

Interestingly, several renowned researchers in nano-science and nanotechnologies communicated to the TAB team, or even publicly commented, that they found the study's discussion of futuristic visions and description of the networks promoting them very useful. The TAB team's initial concerns that discussing these often far-fetched visions in a study which would become an official document of the parliament and an influential early publication on nanotechnology could cause irritation thus proved to be unfounded. Subsequently, TAB was requested to conduct several other projects to explore various issues in the field of converging technologies in more detail: studies on the politics of converging technologies at the international level (Coenen 2008) and on brain research (Hennen et al. 2007), and a study entitled "*Pharmacological and technical interventions for improving performance.* Perspectives of a more widespread use in medicine and daily life ('enhancement')" (see Sauter/Gerlinger 2011 and TAB 2011).

This interest of policymakers in techno-visionary sciences is also evident at the European level, where the field of techno-visionary sciences is being addressed in an anticipatory manner by a fairly large number of projects (see, for example, Coenen et al. 2009b on human enhancement, European Parliament/STOA 2011 on a broad range of technologies) and other advisory activities (see, for example, the activities on nanotechnology, synthetic biology and ICT implants conducted by the European Group on Ethics in Science and New Technologies, EGE). The situation is much the same in the United States (see, for example, PCSBI 2010, i.e. the recent work on synthetic biology by Barack Obama's Presidential Commission for the Study of Bioethical Issues, and the work by George W. Bush's ethics council on human enhancement).

What is still missing, however, is a careful analysis of modified or new requirements concerning sound science-based policy advice in this emerging field. This is the main task of this paper. The notion of '(scientific) policy advice' will serve as an umbrella term for scientific and knowledge-based advice made available to policymakers. In the context of this paper, this always refers to advice on the broad field of science and technology governance described briefly above, including participatory processes. 'Scientific' here means that policy advice is given on the basis of the state of the art in the natural-scientific, social-scientific and humanist disciplines relevant to the given topic of advice.

2 Techno-visionary communication in ongoing debate

In the past decade, there has been a considerable increase in visionary communication on future technologies and their impacts on society. In particular, this has been and still is the case in the fields of nanotechnology (Selin 2008; Fiedeler et al. 2010), human enhancement and the converging technologies (Roco/Bainbridge 2002; Grunwald 2007; Wolbring 2008), synthetic biology (Coenen et al. 2009a) and climate engineering (Crutzen 2006). Visionary scientists and science managers have put forward far-ranging visions which have been disseminated by mass media and discussed in science and the humanities. These observations allow us to speak of an emergence of *techno-visionary sciences* in the past decade.

The emergence of this new wave of visionary and futuristic communication (Coenen 2010, Grunwald 2007, Selin 2008) has provoked renewed interest in the role played by imagined visions of the future. Obviously, there is no distinct borderline between the visions communicated in these fields – I will call them futuristic visions (Grunwald 2007) – and other imagined futures such as *Leitbilder* or guiding visions which have already been analysed with respect to their usage in policy advice (Grin/Grunwald 2000). However, the following characteristics may circumscribe the specific nature of futuristic visions:

- futuristic visions refer to a more distant future, some decades ahead, and exhibit revolutionary aspects in terms of technology and in terms of culture, human behaviour, individual and social issues
- scientific and technological advances are regarded in a renewed techno-determinist fashion as by far the most important driving force in modern society (technology push perspective)
- the authors of futuristic visions are mostly scientists, science writers and science managers such as Eric Drexler and Ray Kurzweil, though industry and CSOs are also developing and communicating visions
- milestones and technology roadmaps are to bridge the gap between today's state and the visionary future state (e.g. Roco/ Bainbridge 2002)
- high degrees of uncertainty are involved; this leads to severe controversies with regard not only to societal issues (e.g. Dupuy 2007) but also to the feasibility of the visionary technologies (e.g. Smalley 2001)

Futuristic visions address possible future scenarios for techno-visionary sciences and their impacts on society at a very early stage in their scientific and technological development. As a rule, little if any knowledge is available about how the respective technology is likely to develop, about the products which such development may spawn and about the potential impact of using such products. According to the Control Dilemma (Collingridge 1980), it is then extremely difficult if not impossible to shape technology. Instead, lack of knowledge could lead to a merely speculative debate, followed by arbitrary communication and conclusions (see Sec. 3.1).[2]

While futuristic visions often appear somewhat fictitious in content, it is a fact that such visions can and will have real impact on scientific and public

[2] One illustrative example is the ongoing debate on "speculative ethics" (Nordmann 2007, Nordmann/Rip 2009, Roache 2008, Grunwald 2010).

discussions (Nowotny et al. 2001). We must distinguish between the degree of facticity of the *content* of the visions and the fact that they are used in genuine communication processes *with their own dynamics*. Even a vision without any facticity at all can influence debates, opinion-forming, acceptance and even decision-making. Visions of new science and technology can have a major impact on the way in which political and public debates about future technologies are currently conducted, and will probably also have a great impact on the results of such debates – thereby considerably influencing the pathways to the future in two ways at least:

- Futuristic visions are able to change the way the world is perceived and increase the contingency of the *conditio humana* (Grunwald 2007). The societal and public debate about the chances and risks of new technologies will revolve around these visions to a considerable extent, as was the case in the field of nanotechnology (cf. Schmid et al. 2006) and as is currently the case in synthetic biology (Coenen et al. 2009a). Visions motivate and fuel public debate because of the impact these visions have on everyday life and on the future of areas of society such as the military, work or health care, and because they are related to some extent to cultural patterns (DEEPEN 2009). Negative visions and dystopias could mobilise resistance to specific technologies.
- Visions have a particularly great influence on the scientific agenda (Nordmann 2004) which, as a consequence, partly determines which knowledge will be available and applicable in the future. Directly or indirectly, they influence the views of researchers, and thus ultimately also have a bearing on political support and research funding. Visions therefore influence decisions about the support and prioritisation of scientific progress. This is an important part of the governance of knowledge (Stehr 2004), as revealed by the sociology of expectations (van Lente 1993, Selin 2008):

The factual importance (power) of futuristic visions in the governance of knowledge and in public debate is a strong argument in favour of providing early policy advice in the fields of techno-visionary sciences with a view to increasing reflexivity and transparency in these debates. Policymakers and society should know more about these visions – they must be informed and "empowered" to deal constructively and reflectively with futuristic visions in processes of "anticipatory governance" and "responsible development".

This conclusion is supported by calls for a more democratic governance of science and technology (Markus/Siune, et al. 2009) on account of the fact that futuristic visions contain a mixture of facts and values, allowing them to be used for ideological and interest-based purposes. Special consideration must therefore be given to the challenge of how democratic deliberation and public debate could be involved in shaping the future course of techno-visionary sciences, taking the described lack of knowledge and the Control Dilemma seriously. An open, democratic discussion of techno-visionary sciences is a prerequisite for a constructive and legitimate approach to shaping the future research agenda, regulations and research funding. The requirement for transparency with respect to future projections and the arguments, premises and visions they comprise is indispensable; this is the main point of entry for identifying challenges to policy advice and for deriving specific requirements for the organisation of policy advice in this field. Another essential point is that democratic debate depends on the capabilities and capacities of people and groups to engage in such debates. Access to adequate resources and information is necessary in general, and particularly when it comes to interpreting and debating futuristic visions.

3 Techno-visionary sciences: Challenges to policy advice

Having set forth arguments in favour of providing scientific policy advice for the governance of techno-visionary sciences despite a lack of knowledge, the next task is to analyse in some depth the specific challenges to policy advice. We need to identify the obstacles, pitfalls, risks and restrictions associated with attempting to meet specific objectives of policy advice in the field of techno-visionary sciences:

- to provide orientation for current decision-making in the field, e.g. with regard to research funding and its influence on the scientific agenda
- to identify possible requirements for regulation (in the case of synthetic biology, for example, risks of bio-safety and bio-security which are frequently debated issues today)
- to inform and enlighten democratic deliberation and public debate in line with theories of deliberative democracy
- to provide society today with better knowledge “about and for us”: “What do these visions tell us about the present, what is their implicit criticism of it, how and why do they require us to change?” (Nordmann 2007, p. 41).

Policy advice on issues of technological progress is usually generated by undertaking future investigations, scenarios and reflections (Grunwald 2009a), in line with the general premise that decision-making processes in modern societies operate by looking to the future rather than the past (e.g. Luhmann 1997). The problem is that the familiar social conflicts will also influence the way the future is considered and assessed (Brown et al. 2000). Social conflicts and scientific controversies make it impossible to obtain converging views on futures (see Grunwald 2011 for the case of energy futures). This makes it more difficult for policy advice to provide orientation. In this section I will take a closer look at those challenges to policy advice that appear to be specific to the field of techno-visionary sciences.

3.1 The arbitrariness problem

A fundamental problem with far-reaching future visions or scenarios is the inevitably high degree to which material other than sound and reliable knowledge is involved. In many cases, entire conceptions of the future, or aspects of it, are simply “accepted” due to a lack of knowledge; this is typical of one of the branches of the Control Dilemma mentioned above. Huge uncertainties enter the field – these are gradually and imperceptibly transformed, first to possible, then plausible and finally probable development paths: “As the hypothetical gets displaced by a supposed actual, the imagined future overwhelms the present” (Nordmann/Rip 2009, p. 273). Indeed, it is not unusual in the field of techno-visionary sciences to include second- or third-level conditionality, namely when certain consequences might occur as a consequence of the use of techno-visionary products that themselves only *might* or *could* become reality, and then only if the respective technical development *were to* take place in the direction envisaged. As a rule, it is also possible in multilevel conditional sentences of this type for the outcome to be precisely the opposite of what was originally assumed. It would then be impossible to decide on which of the contradictory alternatives should be given preference and for which reasons.

Consider, for example, the different views on converging technologies expressed by Dupuy and Grinbaum (2004) and Roco and Bainbridge (2002). The future prospects of the converging technologies show the *maximum conceivable disorientation*: they oscillate between expectations of paradise and of catastrophe. If there were no methods of assessing and scrutinising diverging futures in a "rational" sense, the arbitrariness of futures would destroy any hope of gaining orientation by reflecting on future developments. This was the primary concern resulting from the examination of the debate on "speculative nanoethics" (Nordmann 2007; Grunwald 2010). It is essential that the problem of the feared arbitrariness of futures be satisfactorily resolved, as otherwise the decision-making cycle (Fig. 2) would amount to nothing more than self-deception. Providing orientation by communicating futuristic visions is therefore a highly ambitious and risky undertaking. The arbitrariness problem constitutes a severe challenge and raises doubts about whether such an endeavour could succeed at all. In accordance with the Control Dilemma (Collingridge 1980), it above all imposes limits on the excessive expectations of upstream engagement's ability to shape science and technology; alternatively, it gives rise to a need to develop new ideas to circumvent the Dilemma or, if this is not possible, to deal constructively with it.

3.2 The ambivalence of techno-visionary futures

Public attention has become a scarce commodity in the media society, with the corresponding consequences for the threshold of perceptibility. This leads to inflated scientific promises and announced paradigm changes, and greater expectations of something that is presumed to be "completely new". In futuristic visions, as in the debates on nanotechnology and converging technologies, what is *completely new* is frequently pushed to the foreground by its protagonists, because only in this manner can public and political attention be generated. This communication pattern is obviously not entirely new but has been extensively used over the past decade.

In the field of techno-visionary sciences, the high degree of uncertainty and low level of reliable knowledge mean that this type of communication entails specific risks because it is impossible to obtain a more or less clear picture of future developments and arrive at a (more or less) clear ethical judgment. If the anticipated future developments of techno-visionary sciences diverge dramatically between paradise and apocalypse, ethical assessments of these sciences will diverge in a similar way: "Tremendous transformative potential comes with tremendous anxieties" (Nordmann 2004, p. 4). This will then have dramatic consequences for public debate and public perception of techno-visionary sciences. Using metaphors to describe what is radically and revolutionarily new in terms of scientific-technical visions can backfire; an attempt to fascinate and motivate people by suggesting positive utopias can lead directly to rejection and contradiction. The visionary pathos in many technical utopias is extremely vulnerable to the simple question of whether everything couldn't just be completely different – and it is as good as certain that this question will also be asked in an open society. It is one of the core convictions of large parts of STS, in accordance with the field's underlying social constructivist paradigm, that existing technologies could have developed completely differently and that the development of future technologies is not determined by today's constellations.

Nanotechnology is a good illustration of how positive expectations can be reversed and become sinister fears. Ever since the now-famous article entitled "Why the Future Doesn't Need Us" (cf. Joy 2000) was published, self-reproducing nanobots have no longer been simply a vision intended to help solve humanity's gravest problems (cf. Drexler 1986), but in some cases have been publicly portrayed as a nightmare scenario. This example shows that revolutionary changes promised by new technologies give rise not only to fascination and motivation but also to concern, fear and objection. In the course of time, there may be winners and losers, there may be unexpected and possibly negative consequences, and there will certainly be a large degree of uncertainty. Revolutionary prospects do not automatically lead to positive associations, but may also provoke negative reactions. Futuristic visions may thus lead to a backlash and ultimate rejection rather than fascination and acceptance.

3.3 Lack of transparency

The existence of visionary futures in these fields reveals a high degree of uncertainty. They are difficult to assess with respect to their feasibility and possible impact on future society. Given their considerable impact on the way new technologies are perceived in society and in politics and given that they are an important part of their governance (see Sec. 2), they should be subject to democratic debate and deliberation. The significant lack of transparency and unclear methodical status of futuristic visions are, however, obstacles to transparent democratic debate.

Techno-visionary futures do not exist per se, nor do they arise of their own accord. On the contrary, they are "made" and socially constructed in a more or less complex manner. Futures – be they forecasts, scenarios, plans, programmes, visions, speculative fears or expectations – are "produced" using a whole range of ingredients such as available knowledge, value judgements and suppositions. This construct character of a future, that is to say the fact that its character is the result of a construction process, is particularly true of *scenarios*. The common reference to "scenario building" emphasises this construction process.

Visions of the future are created in accordance with available knowledge, but also with reference to assessments of relevance, value judgements and interests, and are often commissioned by political and economic decision-makers (Grunwald 2011). The construct character of futures can thus be exploited by those representing specific positions on social issues, substantial values and specific interests such that future visions are produced that reflect their interests and can be employed to assert their particular positions in debates (Brown et al. 2000; see also the remarks of the 'deconstructive side' of STS given by Webster 2007). The non-transparent nature of the visions communicated in public debate hinders democratic deliberation.

Visionary futures are frequently created by scientists and science managers who at the same time are stakeholders with their own interests. One possible scenario is that visionary futures suggested by science could dominate social debates by determining their frames of reference; this would leave the social debate with only aspects of minor importance (Nordmann/Rip 2009). In this case, those visionary scientific and technological futures could endanger public opinion-forming and democratic decision-making, thus perhaps constituting a new form of "covert" expertocracy. Against the background of normative theories of deliberative democracy, there is therefore a considerable need to improve transparency in this field.

3.4 Displaced politics?

The question arises whether the emergence of techno-visionary sciences creates or has created new policy rooms (Nowotny 2007) that are related to the communication medium of futuristic visions and new forms of governance. The current situation in the fields of enhancement technologies, synthetic biology and other techno-visionary sciences such as climate engineering might be regarded as an ongoing social experiment. STS research might feel itself to be in a kind of laboratory situation and attempt to directly observe ongoing changes and shifts in the "policy rooms" (Nowotny 2007) that govern the co-evolution of science and technology and society.

This topic covers a variety of subtopics which can be described by asking the following questions: What impact do techno-visionary futures have on politicians and other actors in the overall governance of visionary techno-sciences? Which aspects, properties or attributes of these futuristic visions have a crucial bearing on public opinion-forming and political decision-making processes? How do visions enter other subsystems of society such as the economy, political system or cultural institutions such as education or popular entertainment (films, books)? How are they absorbed by potential users? How are futuristic visions perceived, communicated and used in public debate? Research should also consider the role of scientific policy advice (i.e. parliamentary technology assessment and expert groups) as an intermediary channel for transferring scenarios from the academic to the political arena. Of particular interest, furthermore, is an investigation of how and to what degree futuristic visions structure public debate, influence the perception of risks and opportunities and determine technology acceptance or rejection.

Nahuis and van Lente (2008) refer to the political content and power of otherwise de-contextualised techno-scientific artefacts and related debates. They note that science and technology ''challenge the common meaning of (democratic) politics'', leading to innovation that ''has been conceived of as the continuation of politics with other means'', and is ''most successful when it bypasses established institutions of democratic politics'' (Nahuis/van Lente 2008, p. 560; Kastenhofer 2010). Other forms of displacement such as 'displaced technology', 'displaced sociality', 'displaced naturality' or 'displaced science' could be appropriate attributes if the hybrid character of techno-science is taken seriously (Kastenhofer 2010) – a hybrid character which is also evident in the futuristic elements of the ongoing communication on techno-visionary sciences. The landscape of the "policy rooms", where governance of techno-visionary sciences takes place, is changed by displacements, shifts and the dissolution of communication borders or the creation of new boundaries and boundary objects. Policy advice in these fields should be well-informed about these developments precisely because it has to operate in this changing environment.

4 Conclusions about a research programme in STS and TA

To meet the aforementioned challenges, one must build on existing experiences, bodies of knowledge and competencies of established policy advice approaches and concepts. This must be complemented by new approaches to research, analysis and assessment for societal debates on techno-visionary sciences.

4.1 Understanding the biography of futuristic visions

Futuristic visions are created and disseminated by authors, teams, scientists and science managers, or emerge from discourse within scientific communities. They are communicated via different channels, journals, networks, mass media, research applications etc. Some of them, finding no resonance, will "die" within these communication processes, while others will "survive" and motivate actors and groups to subscribe to or oppose the visions – in either case the story will continue. Only a few of the visions will find an audience via the mass media and will therefore be able to bring about "real" impact by influencing public debate and social perception or attitudes. Others may enter the political arena and result in political decisions, e.g. about research funding, and may then disappear.

These different "biographies" of futuristic visions could be extended by examining their historical roots (Coenen 2010) and the resonances they may subsequently generate. In this sense we could regard futuristic visions as part of an ongoing societal and scientific communication process in which specific visions – e.g. the molecular assembler (Drexler 1986) or enhancement of the brain's capability – act as the necessary catalysts with their own individual "biography" or "life cycle".

Biographies of futuristic visions are not well understood as yet. There is a particularly low level of knowledge about the factors that determine whether a particular vision will "die" (i.e. whether it will disappear during the course of the communication process without having had any impact) or will "survive" and stimulate further communication, possibly influencing societal perception and political decision-making. The entire 'life cycle' of futuristic techno-visions, from construction to assessment and impact, thus raises a huge variety of research questions which can only be answered by giving interdisciplinary consideration to all three aspects. The main objective would be to generate more knowledge about and greater insights into the social processes surrounding visionary futures, from their emergence and dissemination via different communication channels to their possible impact on decision-making in the policy arena and other arenas of public communication and debate. Innovative formats for improving communicative practice should be developed on the basis of this knowledge (Markus/Siune, et al. 2009). This may contribute to a 'normalisation' of techno-visionary sciences (see Grunwald/Hocke-Bergler 2010 for the case of nanotechnology). Generally, normalisation means that the perception of new and emerging science and technology (NEST) shifts from 'revolutionary' to more or less 'normal', displaying the familiar ambivalences as regards risks/ opportunities.

4.2 Epistemological deconstruction of techno-visionary futures

The arbitrariness problem (see Sec. 3.1), namely that reliable conclusions based on the usual scientific standards cannot be drawn if merely speculative and arbitrary futures are addressed (Hansson 2006), can be regarded as a challenge to epistemology, though it may be possible to avoid complete arbitrariness, at least to a certain degree. In order to deal constructively with the challenge of arbitrariness, methods and procedures for assessing the degree of rationality behind visions and images of highly uncertain futures must be developed. Deconstruction (see Webster 2007) must not only clarify the cognitive and normative content of the partially speculative future conditions but also assess their validity: "Instead of welcoming without scrutiny anyone who cares to add to the stock of promises and concerns about nanotechnology, we need to encourage discussions about quality of promises." (Nordmann/Rip 2009, 274)

Epistemological "deconstruction" of visionary statements is necessary in order to be able to qualify the object of subsequent ethical reflection or public debate, for example, with regard to its applicability and validity. Epistemological analysis of future conditions would initially have to uncover the cognitive content of the visions, i.e. the portions of knowledge and lack of knowledge that are involved, their respective premises, and the way they are combined to form coherent images of the future, such as scenarios. An important aspect would then be to examine the conditions necessary for such futures to become reality and the periods of time involved. Furthermore, the *normative content* of the visions would have to be reconstructed analytically: the images of a future society or human development, and the possible diagnoses of current problems, the solutions to which are supposed to be facilitated by the techno-visionary developments.

The de facto importance of futuristic visions in the nano debates was the main argument for postulating early vision assessment in order to allow for more rationality, reflexivity and transparency (Grunwald 2009b) consisting of an epistemological, a hermeneutical and an empirical division. Deconstruction thus not only means a philosophical endeavour rooted in epistemology, but should also include a deconstruction of the social processes involved in the construction, dissemination and use of elements of techno-visionary communication. In this way, both philosophical analysis and STS research are needed.

4.3 Hermeneutical reconstruction

In response to the issue of non-transparency (see Sec. 3.3), tools and methods must be developed and applied which allow the content of the visions debated in the field of techno-visionary sciences to be revealed (e.g. Pawson et al. 2005). Such visions must be made the subject of prospective *hermeneutical* analysis in order to better understand the content of the visions. The more speculative the considerations of the consequences and impacts of techno-visionary sciences, the less they can serve as direct orientation for concrete (political) action and decisions. Instead, conceptual, pre-ethical, heuristic and hermeneutic issues then assume greater significance by contrast. The primary issue is then to clarify the meaning of the speculative developments: what is at issue; which rights might possibly be compromised; which images of humankind, nature and technology are formed and how do they change; which anthropological issues are involved; and which designs for society are implied in the projects for the future?

Thinking about these issues is obviously not aimed at direct policy action but is more about understanding what is at stake and issue in the debates on nanotechnology – contributing to a 'hermeneutics' of possibly changing elements of the *condition humaine*. In this way, hermeneutical reflection based on philosophical and social science methods such as discourse analysis can prepare the groundwork for anticipatory governance informed by applied ethics and technology assessment. Ultimately, this may promote democratic debate on scientific-technical progress by investigating alternative approaches to the future of humans and society with or without different techno-visionary developments. However, this would necessitate additional effort to make issues transparent and understandable to non-academics.

This "hermeneutics" of visions should address not only the cognitive but also the normative content of the visionary communication, both of which are culturally influenced. In a normative respect this would mean preparatory work for ethical analysis. As regards cultural issues, hermeneutical analysis could result in better understanding of the origins and roots of the visions by uncovering underlying cultural elements. An example of this type of analysis can be found in the DEEPEN project (DEEPEN 2009, von Schomberg 2010). One of the findings was that cultural narratives such as "Opening Pandora's box" and "Be careful what you wish for" also form the backdrop to many of the visionary public debates and concerns.

The expectation is that hermeneutical analysis and reconstruction will help realise orientation functions of futuristic visions, thus addressing at least to a certain extent the problems of ambivalence (Sec. 3.2) and lacking transparency (Sec. 3.3). It might benefit from recent thoughts on how to bring STS more constructively into a position of engagement with science and technology policy. Webster (2007), referring to the long-standing critical thrust of STS analysis, asks quite explicitly how science, technology and the social relationships on which they are based can be reconstructed in a more socially useful way (p. 460). He also acknowledges that the STS critic embraces normative intervention into ongoing governance processes; this comes close to the picture of technology assessment which was introduced in Sec. 1 – STS as a reconstructive approach is supposed to "make a difference" by providing socially robust insights that contribute to both more democratically and more technically warranted knowledge (p. 460).

If these general thoughts are applied to the field of techno-visionary sciences, it would appear that they are in line with more philosophical ideas of a hermeneutical reconstruction of futuristic visions – this *reconstruction* must necessarily be based on an epistemological and social *deconstruction* of these futures (Sec. 4.2).

4.4 The changing nature of participation

For years, participation in technology assessment was regarded as a key approach to more democratic governance of science and technology (Joss/Belucci 2002). The initial constellation was rather simple: TA institutions and projects were supposed to advise political institutions such as parliaments and governments, and many of them used participatory procedures to provide more socially robust advice, or advice based on greater legitimacy. This tradition in itself gave rise to many problems with achieving the far-reaching objectives, such as problems with selecting participants, problems with legitimacy and problems with transferring the results of participatory processes to formal decision-making procedures and problems.

In the field of techno-visionary sciences, however, things become even more complicated if the challenges mentioned in Sec. 3 are taken seriously. The following quote – read "techno-visionary sciences" for "technosciences" – may serve as an illustration of the increased complexity of governance in this field: "The role of technoscience as serving as a boundary object between science, technology and society can be interpreted even more broadly. Technoscience then becomes a kind of ''magic gate'' to introduce social, cultural and political elements into the scientific realm, and from there into the economic and industrial sphere, and vice versa. As soon as such aspects (be they objects, actors, discursive rationalities or governance regimes) leave their original sphere, they become intangible for instruments, mechanisms and actors pertinent to this sphere while still staying powerful" (Kastenhofer 2010).

The classic borders between political institutions, TA institutions and citizens become blurred in the field of techno-visionary sciences. The formerly rather clear images about the technology under consideration (take a nuclear waste disposal site, for example, or elements of new traffic infrastructure) are, in this field, elements of a highly uncertain future: whereas people in the past would be concerned or affected by specific technologies which had an impact on their concrete interests, there is now a shift towards a mere feeling of fascination or unease about techno-visionary sciences, and clear decisions that need to be taken are transformed into broader but indistinct images of future developments or of the "future of human nature" (Habermas 2001). What could participation contribute to governance of science and technology in these new "policy rooms" and what form might it take in terms of approaches and methods? Classical instruments such as consensus conferences or scenario workshops may well fail: "Public engagement is full of tensions, and after the recent wave of enthusiasm, it is time to consider renewal, at least in its relation with governance of science-in-society" (Markus/Siune, et al. 2009).

Even at the objectives level, participation may need to be completely re-invented from scratch. Rather than providing additional knowledge and diverse perspectives and values, thereby enriching concrete decision-making processes, the main task now would shift to hermeneutical work, in line with Sec. 4.3. However, how should people be motivated to engage in participatory processes where no concrete decisions are to be shaped or supported? Why should they spend their time at round table meetings or in focus groups where values and "grand issues" are at stake but no personal interests are affected? The changing nature of participation is also evident from the additional actors who are entering the game: "With the many upstream and midstream engagement exercises, the expectation of more to come, and thus a certain institutionalization of public engagement (in its various forms), a new kind of actor has emerged, the engagement mediator, consultant and entrepreneur. This will professionalize public engagement, so that it will be more immediately productive, but it may also undermine the original intent of deliberative democracy" (Markus/Siune, et al. 2009).

There is also a danger that participation in the field of techno-visionary sciences will amount to nothing more than mere conversation, as was found to be the case in the field of "speculative nano-ethics" (DEEPEN 2009). Altogether, it seems that an in-depth review of participation is necessary in this field, including an analysis of the mistrust displayed towards participation following suspected misuse due to partisan interests, when for example acceptance is simply created for decisions already taken.

5 Perspectives

Based on the observation that futuristic visions can strongly influence the scientific agenda, political decision-making, public attitudes and the structure of risk and opportunity debates, tools need to be provided that allow transparent democratic debate about the different and possibly completely diverging futures. Research for policy advice should develop and use such tools as were described in Sec. 4 in order to support, enable and empower public debate as well as decision-making.

Policy advice must build on scientific knowledge and deal with uncertainties. Considerable requirements and challenges in the field of techno-visionary sciences mean that new and emerging assessment regimes (Kaiser et al. 2010) must be used and transformed into an advisory structure. According to current requirements for science governance, this advisory structure should address not only political institutions and policy-makers in a traditional sense but all stakeholders involved (Markus/Siune, et al. 2009). In particular, it should allow a transparent democratic debate about the different visionary futures put forward by different actors. Vision assessment, being a combination of social science and STS research into the biography of visions, epistemological effort and explorative hermeneutics, allows better-informed and more rational opinion-forming, assessment and decision-making (Sec. 4).

This result demands that widely-used classical approaches to research and policy advice, such as technology assessment, applied ethics and STS research, should converge or at least undergo a process of mutual learning. Among other things, the MASIS expert group (Markus/Siune, et al. 2009), which brought together STS researchers and TA practitioners, found that converging perspectives could be developed at a rather high degree of abstraction. Notions such as 'reflective science' and 'responsible innovation' (see below) served as common frames for describing changing relations between science, technology and society over the past decades. Viewed from a TA perspective, however, stories about such notions are only part of the game resulting from observations made by a distant observer – typically from a STS perspective. The much more 'down to earth' business of TA being involved in concrete arenas of deliberation and conflict and having to deal with particular persons, groups and even societal forces takes place at a different level. Mutual learning processes might help bridge this obvious gap.

In the field of techno-visionary sciences, these learning processes can be organised as (1) distant observation versus engagement, (2) fact provision versus hermeneutical analysis and (3) deconstruction versus reconstruction.

(1) The analysis given in this paper shows that the metaphor of epistemological fence-sitting (Webster 2007) mentioned earlier and the need for engagement should not be seen as an "either/or" choice. Analysing visionary communication and communicating the results of this analysis again constitutes an intervention in ongoing communication. Thus epistemological "fence-sitting" is not possible in a puristic sense in the field of techno-visionary sciences: analysis always implies intervention. On the other hand, this must not mean that policy advice becomes an intrinsic part of policy: "At the same time, we cannot simply become a branch of policy: independent STS critique, not least of the economic and political interests informing policy options, must be the *first* priority for the field." (Webster 2007, 474)

Maintaining the difference between scientific policy advice and policy is essential for its legitimisation and appreciation. Both engagement and scientific observation of ongoing developments are therefore essential to ensure legitimate and sound scientific policy advice. The TA experience in engagement and the STS experience in observation could benefit from one other.

(2) Traditionally, TA has been expected to deliver – as far as possible – facts about the future consequences of science and technology. In the field of techno-visionary sciences this is virtually impossible (Sec. 3); instead, hermeneutical and epistemological analysis is required (Sec. 4). In this respect, TA as scientific policy advice could benefit from the experience gained in this direction by STS.

(3) Policy advice generally has to analyse and "deconstruct" arguments and debates in order to reconstruct them in a transparent way. In the field of techno-visionary sciences, the interplay between deconstruction and reconstruction (Webster 2007) becomes even more important because of the threats of arbitrariness and ambivalence (Sec. 3).

The ideas of 'responsible development' in scientific-technological progress and of 'responsible innovation' in the field of new products, services and systems have been discussed with increasing intensity for some years now (Markus/Siune, et al. 2009) and have led to the phrase 'Responsible Research and Innovation' (RRI) being coined (von Schomberg 2012). The postulate of responsible innovation adds explicit ethical reflection to Technology Assessment (TA) and science, technology and society (STS) studies and includes them all in integrative approaches to shaping technology and innovation. On the one hand it focuses particularly on the notion of responsibility and its close relationship with the ethics of responsibility, e.g. in the tradition of Hans Jonas (1979) and his successors. On the other hand, this notion can bridge the gap between technology assessment and engineering ethics. Accordingly, RRI would allow for a more integrative perspective on ethical issues of technology design and development. Until now, however, it has more or less been an empty signifier that requires much greater clarification for it to become usable.

Responsible innovation brings together TA with its findings with respect to assessment procedures, actor involvement, foresight and evaluation with ethics, in particular within the framework of responsibility, as well as building on the body of knowledge about R&D and innovation processes provided by STS and STIS studies (science, technology, innovation and society). Regarding the fact that the very idea developed in the context of debating nanotechnology and society issues, and keeping in mind that nanotechnology is one of the major manifestations of techno-visionary sciences, it seems plausible that RRI will be an appropriate framework within which to analyse the themes put forward in this paper in depth and to develop answers to the questions raised and solutions to the challenges ahead.

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