Chapter 2
Technology Assessment for Responsible Innovation

Armin Grunwald

Abstract The ideas of 'responsible development' in the scientific-technological advance and of 'responsible innovation' in the field of new products, services and systems have been discussed for some years now with increasing intensity. Some crucial ideas of Technology Assessment (TA) are an essential part of these debates which leads to the thesis is that TA is one of the main roots of Responsible Innovation. This can be seen best in the effort which has recently been spent to early and upstream engagement at the occasion of new and emerging science and technology. However, Responsible innovation adds explicit ethical reflection to TA and merges both into approaches to shaping technology and innovation: Indeed, the field of the ethics of responsibility and its many applications to the scientific and technological advance is the second major root of Responsible Innovation. Responsible Innovation brings together TA with its experiences on assessment procedures, actor involvement, foresighting and evaluation with engineering ethics, in particular under the framework of responsibility. The chapter describes both, TA and engineering ethics, as origins of 'Responsible Innovation'.

2.1 Introduction and Overview

The advance of science and technology has for decades been accompanied by debates in society and science on issues of risks and chances, potentials and side effects, control and responsibility. Approaches such as Technology Assessment (Decker and Ladikas 2004; Grunwald 2009), social shaping of technology (Yoshinaka et al. 2003), science and engineering ethics (Durbin and Lenk 1987) and Value Sensitive Design (van de Poel 2009) have been developed and are practiced to a

A. Grunwald (✉)
Karlsruhe Institute of Technology, Karlstr. 11, 76133 Karlsruhe, Germany
e-mail: armin.grunwald@kit.edu

J. van den Hoven et al. (eds.), *Responsible Innovation 1: Innovative Solutions for Global Issues*, DOI 10.1007/978-94-017-8956-1_2,

certain extent. All of them have a specific focus, particular theoretical foundations, different rationales, and have been conceptualised for meeting differing challenges and context conditions. All of them also show strengths and weaknesses and specific limitations to application. Therefore, the search for new and better concepts is ongoing – and will, probably, never come to an end. The field of interest – scientific and technological advance – continuously creates new developments with new challenges to analysis, assessment and debate leading to the demand for new conceptual and methodological approaches.

The ideas of 'responsible development' in the scientific-technological advance and of 'responsible innovation' in the field of new products, services and systems have been discussed for some years now with increasing intensity. The technology field in which most of this development took place has been nanotechnology. One of the many examples where responsible development and innovation in this field are postulated is:

> Responsible development of nanotechnology can be characterized as the balancing of efforts to maximize the technology's positive contributions and minimize its negative consequences. Thus, responsible development involves an examination both of applications and of potential implications. It implies a commitment to develop and use technology to help meet the most pressing human and societal needs, while making every reasonable effort to anticipate and mitigate adverse implications or unintended consequences. (National Research Council 2006, p. 73)

This request takes up formulations well known from the history of Technology Assessment (TA) (Grunwald 2009). However, there are new accentuations, shifts of emphasis and some new aspects. My thesis is that TA is one of the main roots of Responsible Innovation (Sect. 2.2). Based on earlier experiences with new technologies such as genetic engineering and with corresponding moral and social conflicts, a strong incentive is to 'get things right from the very beginning' (Roco and Bainbridge 2001).

Early engagement has received increasing awareness in TA over the past decade mainly at the occasion of debates on new and emerging science and technology (NEST) such as nanotechnology, nano-biotechnology and synthetic biology. These fields of development show a strong "enabling character" and will probably lead to a manifold of applications in different areas which are extremely difficult to anticipate. This situation makes it necessary – from a TA perspective – to shape TA as an *accompanying process* reflecting on the ethical, social, legal and economic issues at stake. This process should start in early stages of research and development in order to deal constructively with the Control Dilemma (Collingridge 1980). The notion of "real-time TA" partially refers to this challenge (Guston and Sarewitz 2002).

Responsible innovation adds explicit ethical reflection to this "upstream movement" of TA and includes both into approaches to shaping technology and innovation: The field of the ethics of responsibility and the many applications to the scientific and technological advance is the second major root of Responsible Innovation (see Sect. 2.3). Responsible Innovation brings together TA with its experiences on assessment procedures, actor involvement, foresighting and evaluation with engineering ethics, in particular under the framework of responsibility. Ethical reflection and technology assessment, until recently undertaken more at a distance from R&D and innovation, are increasingly taken up as integrative part of R&D programmes (Siune et al. 2009). Science institutions, including research funding agencies, have started taking a pro-active role in promoting integrative research and development. Thus, the governance of science and of R&D processes is changing which opens up new possibilities and opportunities for involving new actors and new types of reflection.

This paper aims at unfolding the theses briefly outlined above. Short introductions into TA (Sect. 2.2) and the notion of responsibility (Sect. 2.3) are required to characterize Responsible Innovation and to identify its innovative aspects (Sect. 2.3).

2.2 Technology Assessment – Roots and Concepts[1]

Technology Assessment (TA) emerged in the 1970s as a science-based and policy-advising activity (Bimber 1996). In its first period technology was regarded to follow its own dynamics (technology determinism) with the consequence that the main task of TA was seen in its early-warning function in order to enable political actors to undertake measure to, for example, compensate of prevent anticipated negative impacts of technology. The dimension of research and development at the lab level was not addressed at all at that time. This changed completely during the 1980s following the social constructivist paradigm leading to the slogan “shaping of technology” (Bijker et al. 1987; Bijker and Law 1994). By following this framework the approach of Constructive Technology Assessment (CTA) was developed (Rip et al. 1995). CTA began to consider activities at the lab level and in innovation processes (Smits and den Hertog 2007). TA for orientating giving shape to new technology and possibly resulting innovations is since then part of the overall TA portfolio reaching from the political, in particular parliamentarian, level far away from the lab up to concrete intervention in engineering, design and development at the level of research programmes and the concrete work at the lab.

2.2.1 The Demand for TA and Its Development Over Time

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

[1]This Section summarizes the description of TA to be published in the Handbook “Design for Value” (ed. Ibo van de Poel, forthcoming) focusing on its relevance to Responsible Innovation. For a general and more detailed introduction into TA see Grunwald (2009).

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

Since the 1960s adverse effects of scientific and technical innovations became obvious some of them were of dramatic proportions: accidents in technical facilities (Chernobyl, Bhopal, Fukushima), threats to the natural environment (air and water pollution, ozone holes, climate change), negative health effects as in the asbestos case, social and cultural side effects (e.g., labour market problems caused by productivity gains) and the intentional abuse of technology (e.g. the attacks on the World Trade Centre in 2001). The emergence of such unexpected and serious negative 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.

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

Parallel to these developments, broad segments of Western society were confronted with predictions of "Limits of Growth" (Club of Rome) in the 1970s which, for the first time, addressed the grave environmental problems perceived as a side effect of technology and economic growth. The optimistic pro-progress assumption that whatever was scientifically and technically new would definitely benefit the individual and society was challenged. As of the 1960s deepened insight into technological ambivalence led to a crisis of orientation in the way society dealt with science and technology. This (persistent!) crisis forms the most essential motivation of the emergence of TA.

New and additional motivations entered the field of TA over the past decades, leading more and more to a shift from the initial emphasis on early warning towards "shaping technology" according to social values:

- *Concerns of an emerging technocracy*: from the 1960s on there have been concerns that the scientific and technological advance could threaten the functioning of democracy because only few experts were capable of really understanding the complex technologies (Habermas 1970). The technocracy hypothesis was born painting a picture of a future society where experts would make the decisions with respect to their own value systems. One of the many origins of TA is to counteract and to enable and empower society to take active roles in democratic deliberation on science and technology (von Schomberg 1999).
- *Experiences of technology conflicts and of legitimacy deficits*: little acceptance of some political decisions on technology (such as on nuclear power in some countries), doubts about their legitimacy and resulting conflicts motivated TA to think about procedures of conflict prevention and resolution, in particular including participatory approaches (Joss and Belucci 2002).
- *Shaping technology according to social values*: In addition to the idea of procedural approaches to legitimisation issues and conflicts (see above) the approach was born to design technology according to social values – if this would succeed, so the hope, problems of rejection or non-acceptance would no longer occur at all, and a "better technology in a better society" (Rip et al. 1995) could be reached. This line of thought seems to be one of the main sources of Responsible Innovation.
- *Innovation issues*: in the past two decades innovation problems of Western societies became obvious. Related with new political efforts and incentives towards innovation TA was faced with new themes, tasks and motivations. TA was increasingly considered part of regional and national innovation systems (Smits and den Hertog 2007). It also has been expected to contribute to Responsible Innovation (Siune et al. 2009).
- *Shift in the societal communication on new and emerging science and technology (NEST)*: techno-visionary sciences such as nanotechnology, converging technologies, enhancement technologies and synthetic biology entered the arena. The widespread use of visions and metaphors marks the expected revolutionary advance of science in general and became an important factor in societal debates (Grunwald 2007; Selin 2007)

Compared to the initial phase of TA a considerable increase of its diversity and complexity can be observed. In modern TA, it is often not only a question of the consequences of individual technologies, products, or plants, but frequently of complex conflict situations between enabling technologies, innovation potentials, fears and concerns, patterns of production and consumption, lifestyle and culture, and political and strategic decisions (Bechmann et al. 2007; Grunwald 2009; von Schomberg 2012).

2.2.2 TA Approaches and Concepts

Technology Assessment (TA) constitutes an interdisciplinary research field aiming at, generally speaking providing knowledge for better-informed and well-reflected decisions concerning new technologies (Grunwald 2009). Its initial and still valid motivation is to provide answers to the emergence of unintended and often undesirable side effects of science and technology (Bechmann et al. 2007). TA shall add reflexivity to technology governance (Aichholzer et al. 2010) by integrating any available knowledge on possible side effects at an early stage in decision-making processes, by supporting the evaluation of technologies and their impact according to societal values and ethical principles, by elaborating strategies to deal with the uncertainties that inevitably arise, and by contributing to constructive solutions of societal conflicts. There are four partially overlapping branches of TA addressing different targets in the overall technology governance: TA as policy advice, TA as medium of participation, TA for shaping technology directly, and TA in innovation processes:

1. TA has initially been conceptualised as *policy advice* (Bimber 1996; Grunwald 2009). The objective is to support policymakers in addressing the above-mentioned challenges by implementing political measures such as adequate regulation (e.g. the Precautionary Principle), sensible research funding and strategies towards sustainable development involving appropriate technologies. In this mode of operation TA does not *directly* address technology development but considers the *boundary conditions* of technology development and use. *Parliamentary* TA is a sub-category of policy-advising TA presupposing that parliaments play a crucial or at least an important and relevant role in technology governance. In an analysis of the roles of parliamentary TA in technology governance based on a theory of institutions, a variety of possible combinations of different institutional configurations occurs (Cruz-Castro and Sanz-Menendez 2004), which is also enriched by the characteristics of the democratic institutions of a nation state and various political traditions (Vig and Paschen 1999).
2. It became clear during the past decades that citizens, consumers and users, actors of civil society, stakeholders, the media and the public are also engaged in technology governance in different roles. Participatory TA developed approaches to involve these groups in different roles at different stages in technology governance (Joss and Belucci 2002). According to normative ideas of deliberative democracy the assessment of technology should be left neither to the scientific experts (expertocracy) nor to the political deciders alone (decisionism) (see Habermas 1970 to this distinction). Participative TA procedures are deemed to improve the practical and political legitimacy of decisions on technology. The participation of citizens and of those affected is believed to improve the knowledge basis as well as the values fundament on which judgements are based and decisions are made. Participation should make it possible for decisions on

technology to be accepted by a larger spectrum of society despite divergent normative convictions. Several approaches and methods have been developed and applied in the recent years, such as consensus conferences, citizens' juries, and focus groups (Joss and Belucci 2002).

3. Building on research on the genesis of technology made in the framework of social constructivism (Bijker et al. 1987) the idea of *shaping technology* due to social expectations and values came up and motivated the development of several approaches such as Constructive TA (CTA) or Social Shaping of Technology (Yoshinaka et al. 2003). They all aim at increasing reflexivity in technology development and engineering by addressing the level of concrete products, systems and services, going for a "better technology in a better society" (Rip et al. 1995). In the engineering sciences, the challenges with which TA is confronted have been discussed as demands on the profession of engineers. Within the various approaches which can be subsumed under the social constructivist paradigm, the impact of those activities is primarily seen in the field of technology itself: ethical reflection aims to contribute to the technology paths, products and systems to be developed (Yoshinaka et al. 2003).
4. 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. This is 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. There is a shift of emphasis from "shaping technology" to "shaping innovation".

From its very beginning TA has been confronted with expectations to contribute to research, development and innovation by adding reflexivity, by including perspectives different from those of scientists, engineers and managers, by taking into account (even uncertain) knowledge about consequences and impacts of new science and technologies, and by transforming all these elements into advice to policymakers and society. Responsible innovation draws on the body of knowledge and experience provided by TA's history over decades – but also extends the scope of consideration to ethical issues, in particular to issues of responsibility. In this sense, there is a second major origin of Responsible Innovation: the fields of ethics of responsibility which will shortly been described in the following section.

2.3 Engineering Ethics and the Issue of Responsibility[2]

The broader debate on the ethics of technology and in particular on the responsibility of engineers started in the 1960s, around some issues of non-intended side-effects of technology, primarily in the field of environmental problems. However, it had long been a matter of controversy whether science and engineering have any morally relevant content at all. Until into the 1990s, technology was frequently held to be *value neutral*. Numerous case studies have, however, since recognized the normative background of decisions on technology and made it a subject of reflection (van de Poel 2009). The basic assumption in this transition is that technology should not be viewed solely as a sum of abstract objects or processes, but that the fact should be taken seriously that it is embedded in societal processes (Rip et al. 1995). There is no "pure" technology in the sense of a technology completely independent of this societal dimension. Technology is thus inherently morally relevant, particularly concerning its purposes and goals, the measures and instruments used, and the evolving side effects. Therefore, technology is an appropriate subject for reflections on responsibility (Jonas 1979; Durbin and Lenk 1987).

This is also true of science. The value neutrality of science was postulated in the era of positivism. Since then, there have been many developments that lead one to think about the ethical aspects of science and about science as being subject to human responsibility. Science – analogously to technology – is not operating in an abstract space and does not work by contemplating about how nature works; it is rather involved in societal purposes and strategies: it is science *in* society (Siune et al. 2009). Scientific knowledge not only explains nature but also delivers knowledge for action, manipulation, and intervention. In particular, 'explaining nature' often requires certain types of – mostly technical – intervention.

Consequently, the concept of responsibility has been used repeatedly in connection with scientific and technological progress in the past two to three decades (Durbin and Lenk 1987). It associates ethical questions regarding the justifiability of decisions in and on science and technology with the possible actions of concrete persons and groups and with the challenges posed by uncertain knowledge of the consequences. As a consequence, several commitments of engineering associations to social and moral responsibility were made. Codes of conduct are now established in several associations. On example is the system of engineering values identified by VDI (German Engineering Association) (VDI 1991).

In usages of the notion of responsibility a more or less clear meaning of this notion is mostly simply supposed. "Responsibility" seems to be an everyday word not needing an explanation. However, this might be a misleading assumption, at least in the field of science and technology. A more in-depth view at the concept of responsibility is needed (following Grunwald 1999). Responsibility is result of

---

[2]This brief review of the ethics of responsibility and its role for technology follows my paper to be published in Paslack et al. (2011).

an act of attribution, either if actors attribute the quality to themselves or if the attribution of responsibility is made by others. The attribution of responsibility is itself an act that takes place relative to *rules of attribution* (on this also see Jonas 1979, p. 173). The attribution of responsibility as an active process makes clear that assignments and attributions of responsibility take place in concrete social and political spaces involving and affecting concrete actors in concrete constellations.

The notion of responsibility often is characterized by reconstructions making the places in a sentence explicit which must be filled in to cover the intentions valid in a particular responsibility context (Lenk 1992). A four-place reconstruction seems to be suitable for discussing issues of responsibility in scientific and technical progress:

- *someone* (an actor, e.g. a synthetic biologist) assumes responsibility for
- *something* (such as the results of actions or decisions, e.g. for avoiding bio-safety or bio-security problems) relative to a
- *body of rules* (in general the normative framework valid in the respective situation (Grunwald 2012, Ch. 3; e.g. rules given in a Code of Conduct) and relative to the
- *quality of available knowledge* (knowledge about the consequences of the actions: deterministic, probabilistic, possibilistic knowledge or mere speculative concerns and expectations; cp. von Schomberg 2005 in the context of the Precautionary Principle).

While the first two places are, in a sense, trivial in order to make sense of the word "responsible", the third and fourth places open up essential dimensions of responsibility: the normative rules comprise principles, norms and values being decisive for the judgment whether a specific action or decision is regarded responsible or not – this constitutes the *moral dimension* of responsibility. The knowledge available and the quality of the knowledge including all the uncertainties form its *epistemic dimension*. Reminding the initial observation that the attribution of responsibility is a socially and politically relevant act and influences the governance of the respective field, it comes out as a main result that *all* three dimensions must be considered in prospective debates over responsibility in science and technology:

- the *socio-political dimension* of responsibility mirrors the fact that the attribution of responsibility is an act done by specific actors and affecting others. Attributing responsibilities must, on the one hand, take into account the possibilities of actors to influence actions and decisions in the respective field. On the other, attributing responsibilities has an impact on the *governance* of that field. Relevant questions are: How are the capabilities to act and decide distributed in the field considered? Which social groups are affected and could or should help decide about the distribution of responsibility? Do the questions under consideration concern the "polis" or can they be delegated to groups or subsystems? What consequences would a particular distribution of responsibility have for the governance of the respective field?
- the *moral dimension* of responsibility is reached when the question is posed as to the *body of rules according to which* responsibility *should* be assumed. These rules form the normative context for judging acts to be responsible or

not. Insofar as normative uncertainties arise (Grunwald 2012), e.g., because of moral conflicts, ethical reflection on these rules and their justifiability is needed. Relevant questions are: What criteria allow distinguishing between responsible and irresponsible actions and decisions? Is there consensus or controversy on these criteria among the relevant actors? Can the actions and decisions in question be justified with respect to the rules, values and ethical principles?

- the *epistemic* dimension asks for the quality of the knowledge about the subject of responsibility. This is a relevant issue in debates on scientific responsibility because frequently statements about impacts and consequences of science and new technology show a high degree of uncertainty (von Schomberg 2005). The comment that nothing else comes from "mere possibility arguments" (Hansson 2006) is an indication that in debates over responsibility it is essential that the status of the available knowledge about the futures to be accounted for is determined and is critically reflected from epistemological points of view. Relevant questions are: What is really known about prospective subjects of responsibility? What could be known in case of more research, and which uncertainties are pertinent? How can different uncertainties be qualified and compared to each other? And what is at stake if worse comes to worst?

Debates over responsibility in technology and science frequently are restricted to level (b) and treat exclusively the *ethics* of responsibility. My hypothesis is that the familiar allegations of being simply appellative, of epistemological blindness, and of being politically naïve are related to this approach narrowing responsibility to its moral dimension. The brief theoretical analysis above shows, however, that issues of responsibility are inevitably interdisciplinary. The issue is not one of abstract ethical judgments but of responsible research, development and innovation, which entails the observance of concrete contexts and governance factors as well as of the quality of the knowledge available. Responsible Innovation must be aware of this complex semantic nature of responsibility.

2.4 Responsible Innovation

Responsible Innovation is a rather new element of technology governance. Its emergence (Siune et al. 2009) reflects the diagnosis that available approaches to shape science and technology still do not meet all of the far-ranging expectations. The hope behind the Responsible Innovation movement is that new – or further-developed – approaches could add considerably to existing approaches such as TA and engineering ethics. Indeed, compared to earlier approaches such as SST or CTA there are shifts of accentuation and new focuses of emphasis:

- "Shaping innovation" complements or even replaces the slogan "shaping technology" which characterised the approach by social constructivist ideas to technology. This shift reflects the insight that it is not technology as such which

influences society and therefore should be shaped according to society's needs, expectation and values, but it is innovation by which technology and society interact.
- There is a closer look on societal contexts of new technology and science. Responsible Innovation can be regarded as a further step towards taking the demand pull perspective and social values in shaping technology and innovation more serious.[3]
- Instead of expecting distant observation following classical paradigms of science there is a clear indication for intervention into the development and innovation process: Responsible Innovation projects shall "make a difference" not only in terms of research but also as interventions into the "real world".[4]
- Following the above-mentioned issues, Responsible Innovation can be regarded as a radicalisation of the well-known post-normal science (Funtowitz and Ravetz 1993) being even closer to social practice, being prepared for intervention and for taking responsibility for this intervention.

However, what "responsible" in a specific context means and what distinguishes "responsible" from "irresponsible" or less responsible innovation is difficult to identify. The distinction will strongly depend on values, rules, customs etc. and vary according to different context conditions. Difficulties similar to those appearing in applications of the Precautionary Principle (von Schomberg 2005) probably will occur. The notion of Responsible Innovation as such does not give orientation how to deal with these challenges and difficulties. In the following I would like to propose a conceptual framework which might help clarifying the crucial questions and finding answers to them. My reflection starts by thinking about the preconditions of inquiries and thoughts about ethics and responsibility.

Most of our decisions take the form of goal–means deliberations at the action level (Habermas 1973) without any particular reflection on their normative background and responsibility issues. The discourse level, at which the normative background of decision-making and issues of responsibility will explicitly be the subject of matter, is the exception. The great majority of technology-relevant decisions can be classified as "business as usual" or "standard situation in moral respect" in the following sense (Grunwald 2000, 2012): the normative aspects of the basis for the decision including assumptions about responsibility are not made the object of special reflection, but accepted *as given* in the respective situation, thereby also accepting the elements of the normative framework this entails. The reason is that actors *can assume*, in making these decisions, a normative framework – the basis on which the decision can be made – to be given, including assumptions about the distribution of responsibility. Parts of this normative framework are (national and

[3] An expression of this shift was the strong role of the Societal Panel in the application phase of the MVI programme 'Responsible Innovation'.

[4] This is reflected by the foreseen role of the Valorisation Panels in projects the MVI programme "Responsible Innovation".

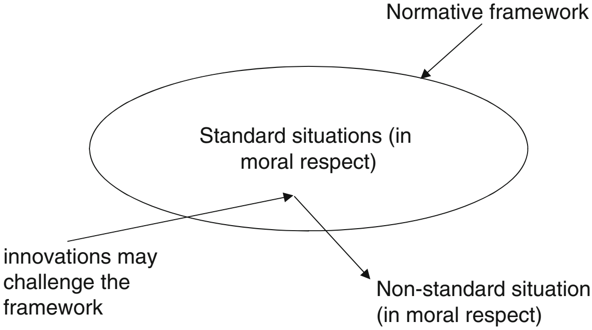

Fig. 2.1 The basic model (Source: Grunwald 2012, Ch. 3)

international) legal regulations, the standard procedures of the relevant institutions (e.g., corporate guidelines), possibly the code of ethical guidelines of the profession concerned, as well as general and un-codified societal customs. The demands on the normative framework which define a business-as-usual situation are formulated more precisely by the following criteria (expanding on Grunwald 2000, 2012):

- *Pragmatic Completeness*
- *Local Consistency*
- *Sufficient Lack of Ambiguity*
- *Acceptance*
- *Compliance*

If these conditions of coherence are satisfied in a specific context, then neither moral conflicts nor ambiguities exist. There is, consequently, no need for explicit ethical reflection and thinking about responsibilities. Participants and others affected by a decision can take information about the normative framework into consideration as axiological information without having to analyze and reflect it. In such "business-as-usual" situations, the *criteria* for making decisions are *a priori* obvious and not questioned (e.g., a cost–benefit analysis in situations in which this is considered an appropriate method according to the accepted normative framework).

However, technical innovations can challenge and possibly "disturb" business as usual situations in moral respect, transform them into non-standard situations and make ethical and responsibility reflection necessary. New scientific knowledge and technological innovation may transform earlier standard situations in a moral respect into *non-standard situations* where one or more of the criteria given above are no longer fulfilled (see Fig. 2.1).

Then, moral ambiguities, conflicts on responsibility and indifferences, as well as new challenges for which moral customs have yet to be established or where there are doubts as to whether established moral traditions apply. In this sense, there is no longer a consensually accepted moral background from which orientation for decision making can be gained. In the following, I will refer to such situations as situations of *normative uncertainty* – then it will be a matter of debate, inquiry or controversy what should be regarded as responsible and what as irresponsible.

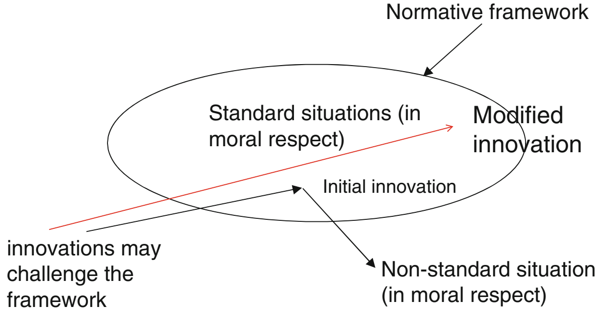

Fig. 2.2 Modify innovation (Source: Grunwald 2012, Ch. 3)

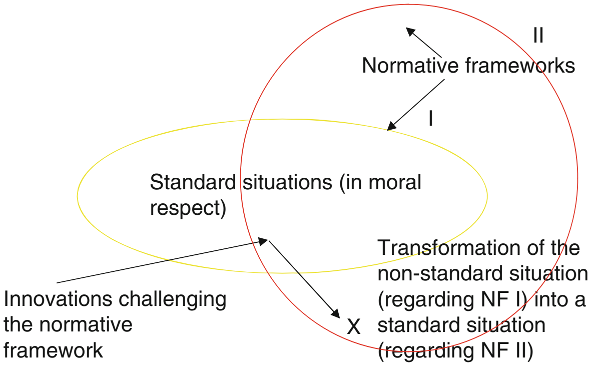

Fig. 2.3 Modification of normative framework (Source: Grunwald 2012, Ch. 3)

In this modified situation, there are simply three options to choose from:

- *The conservative approach*: reject the innovation causing moral trouble – renounce its possible benefits and maintain the initial normative framework.
- *The constructive approach*: Try to modify the properties of the innovation responsible for causing moral trouble (maybe circumstances of its production involving animal experiments or the location of a nuclear waste disposal site in a sacred region of indigenous people) in order to be able to harvest the expected benefits without causing moral trouble (see Fig. 2.2).
- *The techno-optimistic approach*: Modify the normative framework, so that the new technology could be accepted (and the benefits harvested) in a way that would not lead to normative uncertainty and moral conflict (see Fig. 2.3).

Responsibility reflections play a decisive role in determining the criteria of the choice between such alternatives and – in cases 2 and 3 – between different versions and for the concrete consequences. In these cases the reflection is an act of balancing the expected advantages of the innovation or the new technology against the moral or other costs if – as is probably the most common situation – there are no *categorical* ethical arguments for or against. The following can be said about the options:

- *Option 1*: If there would be strong, i.e., categorical, ethical arguments against the new technology then it will probably be rejected. An example is reproductive cloning. Cloning and research on cloning is prohibited in many countries for ethical reasons, and was banned in many Codes of Ethics at the European and international level.
- *Option 2*: The option of shaping technology specifically according to ethical values or principles is behind the approaches of constructive technology assessment (CTA; see Rip et al. 1995), of the social shaping of technology (Yoshinaka et al. 2003), and of value sensitive design (van de Poel 2009, pp. 1001 ff.). The focus is on directing the shaping of technical products or systems along the relevant factors of the normative framework so that the products or systems fit the framework. This would so to speak in itself prevent normative uncertainty from arising.
- *Option 3*: Frequently there are even more complex necessities to balance factors, such as when the (highly promising) use of a new technology or even research on it is not possible except by producing normative uncertainty. Examples are animal experiments undertaken for non-medical purposes (Ferrari et al. 2001) or research in which the moral status of embryos plays a role. The issue is then to examine if and to what extent the affected normative framework can be modified without coming into conflict with the essential ethical principles. Even the handling of technical risks that have to be tolerated in order to utilize an innovation often takes place by means of modifying the normative framework, such as in the implementation of precautionary measures.

Responsibility reflection plays a different role, however, in each of these options. The results of the reflection have to be introduced to the different fields of action (e.g., politics, economics, law). Taking the three dimensions of responsibility mentioned above seriously leads to the conclusion that Responsible Innovation unavoidably requires a more intense inter- and trans-disciplinary cooperation between engineering, social sciences, and applied ethics. The major novelty in this interdisciplinary cooperation might be the integration of ethics (normative reflection on responsibilities) and social sciences such as STS and governance research (empirically dealing with social processes around the attribution of responsibility and their consequences for governance). This integration is at the heart of Responsible Innovation – and a major obstacle might be that applied ethics and social sciences have to deal with deep-ranging controversies and mutual antipathy (Grunwald 1999). It will one of the most exciting challenges in which way these obstacles might be overcome. In the field of technology assessment there are some indications that a constructive cooperation is possible (Grunwald 1999).

The terms of responsible development, responsible research and responsible innovation have been used over the last years to an increasing extent. These terms are highly integrative because they cover issues of engineering ethics, participation, technology assessment, anticipatory governance and science ethics. They include what has been stated in this Chapter about TA: adding reflexivity to technology development and design (see also Voss et al. 2006). In this sense responsible development and innovation might be a new umbrella term (von Schomberg 2012) with new accentuations which may be characterized by:

- involving ethical and social issues more directly in the innovation process by integrative approaches to development and innovation
- bridging the gap between innovation practice, engineering ethics, technology assessment, governance research and social sciences (STS)
- giving new shape to innovation processes and to technology governance according to responsibility reflections in all of its three dimensions mentioned above
- in particular, making the distribution of responsibility among the involved actors as transparent as possible
- supporting "constructive paths" of the co-evolution of technology and the regulative frameworks of society

However, it is important to point out that the model of integrated research including its own ethical and responsibility reflection also harbours problems. The independence of reflection can be threatened especially if the necessary distance to the technical developments and those working on them is lost. Inasmuch as assessment issues becomes part of the development process and would identify itself with the technical success, there might be an accusation that its acceptance was "purchased" or that it was nothing but grease in the process of innovation. Strategies of dealing with such possible developments should be developed and could include means such as careful monitoring activities and a strong role of external review processes. It will be a task for the respective emerging research community around the issue of Responsible Innovation to take care but also the responsible funding agencies should be aware of this challenge.

References

Aichholzer, G., A. Bora, S. Bröchler, M. Decker, and M. Latzer (eds.). 2010. *Technology governance. Der Beitrag der Technikfolgenabschätzung*. Berlin: Edition Sigma.

Bechmann, G., M. Decker, U. Fiedeler, and B.-J. Krings. 2007. Technology assessment in a complex world. *International Journal on Foresight and Innovation Policy* 3: 6–27.

Bijker, W.E., and J. Law (eds.). 1994. *Shaping technology and building society*. Cambridge, MA: MIT Press.

Bijker, W.E., T.P. Hughes, and T.J. Pinch (eds.). 1987. *The social construction of technological systems*. Cambridge, MA: MIT Press.

Bimber, B.A. 1996. *The politics of expertise in congress: The rise and fall of the office of technology assessment*. Albany: State University of New York Press.

Collingridge, D. 1980. *The social control of technology*. New York: St. Martin's Press.

Cruz-Castro, L., and L. Sanz-Menendez. 2004. Politics and institutions: European parliamentary technology assessment. *Technological Forecasting and Social Change* 27: 79–96.

Decker, M., and M. Ladikas (eds.). 2004. *Bridges between science, society and policy. Technology assessment – Methods and impacts*. Berlin: Springer.

Durbin, P., and H. Lenk (eds.). 1987. *Technology and responsibility*. Boston: Reidel Publishing.
Ferrari, A., C. Coenen, A. Grunwald, and A. Sauter. 2001. *Animal Enhancement. Neue technische Möglichkeiten und ethische Fragen*. Bern: Bundesamt für Bauten und Logistik BBL.
Funtowitz, S., and J. Ravetz. 1993. The emergence of post-normal science. In *Science, politics and morality*, ed. R. von Schomberg, 173–188. London.
Gee, D., and M. Greenberg. 2002. Asbestos: From 'magic' to malevolent mineral. In *The precautionary principle in the 20th century. Late lessons from early warnings*, ed. P. Harremoes, D. Gee, M. MacGarvin, A. Stirling, J. Keys, B. Wynne, and S. Guedes Vaz, 49–63. London: Earthscan Publications.
Grunwald, A. 1999. Verantwortungsbegriff und Verantwortungsethik. In *Rationale Technikfolgenbeurteilung*, ed. A. Grunwald, 172–195. Berlin: Springer.
Grunwald, A. 2000. Against over-estimating the role of ethics in technology. *Science and Engineering Ethics* 6: 181–196.
Grunwald, A. 2007. Converging technologies: Visions, increased contingencies of the conditio Humana, and search for orientation. *Futures* 39: 380–392.
Grunwald, A. 2009. Technology assessment: Concepts and methods. In *Philosophy of technology and engineering sciences*, vol. 9, ed. A. Meijers, 1103–1146. Amsterdam: Elsevier.
Grunwald, A. 2012. *Responsible nanobiotechnology. Ethics and philosophy*. Singapore: Pan Stanford Pub.
Guston, D.H., and D. Sarewitz. 2002. Real-time technology assessment. *Technology in Culture* 24: 93–109.
Habermas, J. 1970. *Toward a rational society*. Beacon Press. First publication: Habermas, J. (ed.). 1968. *Technik und Wissenschaft als Ideologie*. Frankfurt.
Habermas, J. 1973. Wahrheitstheorien. In *Wirklichkeit und Reflexion*, ed. H. Fahrenbach, 211–265. Pfullingen: Neske.
Hansson, S.O. 2006. Great uncertainty about small things. In *Nanotechnology challenges – Implications for philosophy, ethics and society*, ed. J. Schummer and D. Baird, 315–325. Singapore: World Scientific.
Harremoes, P., D. Gee, M. MacGarvin, A. Stirling, J. Keys, B. Wynne, and S. Guedes Vaz (eds.). 2002. *The precautionary principle in the 20th century. Late lessons from early warnings*. London: Sage.
Jonas, H. 1979. *Das Prinzip Verantwortung. Versuch einer Ethik für die technologische Zivilisation*. Frankfurt: Suhrkamp.
Joss, S., and S. Belucci (eds.). 2002. *Participatory technology assessment – European perspectives*. London: Westminster University Press.
Lenk, H. 1992. *Zwischen Wissenschaft und Ethik*. Frankfurt: Suhrkamp.
National Research Council. 2006. *A matter of size: Triennial review of the national nanotechnology initiative*. Washington, DC: National Academies Press.
Paslack, R., J.S. Ach, B. Luettenberg, and K. Weltring (eds.). 2011. *Proceed with caution? – Concept and application of the precautionary principle in nanobiotechnology*. Münster: LIT Verlag.
Rip, A., T. Misa, and J. Schot (eds.). 1995. *Managing technology in society*. London: Pinter Publishers.
Roco, M.C., and W.S. Bainbridge (eds.). 2001. *Societal implications of nanoscience and nanotechnology*. Boston: Kluwer.
Selin, C. 2007. Expectations and the emergence of nanotechnology. *Science, Technology and Human Values* 32(2): 196–220.
Siune, K., E. Markus, M. Calloni, U. Felt, A. Gorski, A. Grunwald, A. Rip, V. de Semir, and S. Wyatt. 2009. *Challenging futures of science in society.* Report of the MASIS Expert Group. Brussels: European Commission.
Smits, R., and P. den Hertog. 2007. TA and the management of innovation in economy and society. *International Journal on Foresight and Innovation Policy* 3: 28–52.
van de Poel, I. 2009. Values in engineering design. In *Philosophy of technology and engineering sciences*, vol. 9, ed. A. Meijers, 973–1006. Boston: Elsevier.

VDI – Verein Deutscher Ingenieure 1991. Richtlinie 3780 Technikbewertung, Be-griffe und Grundlagen. Düsseldorf. Available also in English at: www.vdi.de.

Vig, N., and H. Paschen (eds.). 1999. *Parliaments and technology assessment. The development of technology assessment in Europe*. Albany: State University of New York Press.

von Schomberg, R. (ed.). 1999. *Democratizing technology. Theory and practice of a deliberative technology policy*. Hengelo: ICHPA.

von Schomberg, R. 2005. The precautionary principle and its normative challenges. In *The precautionary principle and public policy decision making*, ed. E. Fisher, J. Jones, and R. von Schomberg, 141–165. Cheltenham/Northampton: Edward Elgar.

von Schomberg, R. 2012. Prospects for technology assessment in the 21st century: The quest fort the "right" impacts of science and technology. An outlook towards a framework for responsible research and innovation. In *Technikfolgen abschätzen lehren*, ed. M. Dusseldorp, et al., 43–65. Opladen: Westdeutscher Verlag.

Voss, J.-P., D. Bauknecht, and R. Kemp (eds.). 2006. *Reflexive governance for sustainable development*. Cheltenham: Edward Elgar.

Yoshinaka, Y., C. Clausen, and A. Hansen. 2003. The social shaping of technology: A new space for politics? In *Technikgestaltung: zwischen Wunsch oder Wirklichkeit*, ed. A. Grunwald, 117–131. Berlin: Springer.

Springer

http://www.springer.com/978-94-017-8955-4

Responsible Innovation 1
Innovative Solutions for Global Issues
van den Hoven, J.; Doorn, N.; Swierstra, T.; Koops, B.-J.;
Romijn, H. (Eds.)
2014, XXIII, 392 p. 26 illus., Hardcover
ISBN: 978-94-017-8955-4