Steering for Sustainable Development facing uncertainty and incompleteness of knowledge

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Please notice: this paper is a draft version and includes still parts which are "under construction" (in particular, Sec. 4). In addition, no language proof has been made. Please do not cite and please do use it only for the workshop "Governance for Sustainable Development"! Some parts of the text follow very closely earlier work (Grunwald 2004).

1. Introduction and overview

The idea of Sustainable Development[1] implies that societal processes and structures should be re-oriented so as to ensure that the needs of future generations are taken into account and that current generations in the southern and northern hemisphere are enabled to develop in a way observing justice and equity issues. Thus sustainable development includes necessarily dealing with long term considerations as well as with the global dimension (Kopfmüller et al. 2001). It requires taking into account (normative) aspects of the distant future and issues of equity and justice as well as the relation between society and the natural environment. Furthermore, the impact of such analyses and reflections on our present-day concepts and ideas has to be considered. It is an inherent constituent of the Leitbild of Sustainable Development to think about strategies of shaping the current and future society according to the normative content of sustainability. Therefore, *steering* is necessary and is the ultimate goal of sustainability analyses and assessments. The latter should result, in the last consequence, always in *knowledge for action*, and this knowledge then should motivate and support "real" action (Schomberg 2002).

Steering for sustainable development requires specific types of knowledge to be available (sec. 2). My main task in this paper will be to analyse the gap between the requirements to that knowledge and the possibilities to fulfil them, and to reflect on the consequences of the existence of this gap. The issue of the *uncertainty of knowledge* is at the heart of this gap. I will use the field of shaping technology for sustainable development to identify and clarify issues of uncertainty and incompleteness of knowledge (sec. 3). More general remarks to this issue (sec. 4) will be supplemented by a conceptual analysis concerning different types of uncertainties, their reasons and their degrees. In the final section I will go to discuss the consequences of this situation and the possibilities to deal with them constructively in steering processes, at a conceptual level (sec. 5).

The premises and convictions behind my arguments are:

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[1] The arguments given in this paper are valid independent from the selection of a specific approach to sustainable development.

- uncertainty of knowledge is an indispensable part of the *conditio humana*; it may partly be overcome by research but this research will create other fields of uncertainty;
- in the field of sustainable development uncertainties from different areas merge and create a dramatic increase of the importance and relevance of this issue: the long-term nature of sustainable development, its close relation to both natural and societal fields, its integrative function among incoherent subtopics etc.
- steering for sustainable development, therefore, is not feasible within a classical planning approach; new concepts of approaching the future are needed.
- there is no reason for lamenting about the uncertainties, especially not about the uncertainties concerning future knowledge because uncertainties are the other side of the coin of the openness of the future and the possibilities of shaping the future.
- uncertainties, therefore, only partly disturb the possibilities for steering for sustainable development. On the other side, they allow for learning over time, they allow for adapting and modifying measures due to results of monitoring-processes etc.

2. Steering for Sustainable Development and the need for knowledge

Sustainable development is a normative societal principle, to which's realisation science and research contribute. All scientific research which is carried out in connection with the identification, appraisal, and therapy of sustainability deficits belongs in this category. The knowledge required for sustainability analysis, assessment, and steering is provided on quite different levels and in various manners (Bechmann/Grunwald 2002; Grunwald 2004):

- *empirical observation of developments through time*: The temporal dimension of sustainability implies that problems of sustainability can be ascertained only by the observation of certain parameters through time (as, e. g., the chemical composition of the atmosphere, of soils or water, or of societal phenomena, such as the development of education). Science is therefore in demand for the empirical observation of pertinent indicators over longer periods of time.
- *recognition of cause/effect relationships*: Knowledge of cause/effect relationships forms the basis for modellings, but also for the provision of action-guiding knowledge for dealing with sustainability deficits, and for identifying the right “setscrews“ for political intervention. Study of causal relations extends into basic disciplinary research, such as, e. g., atmospheric chemistry or the political sciences. Research on the causal relations of complex systems at the interface between society and the natural environment is particularly difficult (Schellnhuber/Wenzel 1999; Gethmann/Lingner 2002).
- *extrapolation into the future*: In many cases, it is possible only by means of prognoses to judge whether or not there are sustainability problems (examples would be the development of the climate and of the world population). There is no possibility of experimenting with the real world, but prognoses can be made only by

modelling the system concerned and by simulation (Schröder et al. 2002; Kates et al. 2001; Alcamo 1999; Rotmans 1999; Schellnhuber 1999).

- *development of scenarios*: In many fields, it is no question of prognoses as predictions of future outcomes, but of scenarios as illustrations of *possible* futures, in order to structure the spectrum of further developments, identify “worst-“ and “best“ cases, and to gain strategic knowledge for drawing up action strategies (e. g., Coenen/Grunwald 2003, ch. 5).
- *sustainability assessment and judgment*: Whether certain effects and tendencies are to be interpreted as sustainability problems can not be ascertained from empirical observation or simulation alone, but rather, criteria have to be defined, according to which observations can be classified as more or less relevant for sustainability, or even as a sustainability deficit. The problem of judgement extends to ethical questions of responsibility for the future and to the theory of justice (Sen 1998; Brown-Weiss 1989).
- *ranking of sustainability deficits*: Analysis of the sustainability situation also has to concern itself with assessment of the urgency of certain sustainability problems as opposed to others, and with setting priorities. The possibilities of scientific advice to politics in this field are, however, controversial.
- *interpretation of the results*: The results of modellings, simulations, and assessments need careful interpretation. Besides the possibilities for clarification immanent in the respective discipline, hermeneutics and philosophy of science are also needed (Grunwald/Lingner 2002).
- *response/impact research*: Because – as a rule – competing courses of action and alternative strategies are proposed which are respectively based on different scientific conceptions and normative presuppositions, there is need for the possibility of an *ex ante* comparison for preparation of decisions. Foreseeable effects of the measures proposed (goal attainment, eventual side effects, conditions of implementation) have to be estimated and evaluated. Conceptual and institutional innovations, improvements of technical efficiency, influencing consumption in the sense of sustainability, the question of sustainability-promoting societal terms of reference are only some of the components of such action strategies (Rotmans 1999).
- *verification of the measures and monitoring their effects*: Measures have to be "monitored" in the sense that their effects have to be traced and then compared to the initial goals and expectations. This process allows for adapting and modifying, and optimising the measures.
- *retracing deviations from goal attainment*: In order to make learning possible, the causes of deviations from the “real“ effects in comparison with the expectations held *ex ante*, in particular, have to be investigated. In this manner, comprehension of the system can be improved, and be used for the development of modified or new measures founded on this basis.

The knowledge gained in these varied fields of scientific research can be categorized according to the types of knowledge: explanatory knowledge, orientation knowledge, and action-guiding knowledge (Weber/Whitelegg 2003, Grunwald 2004):

- *System Knowledge*: Sufficient insight into natural and societal systems, as well as knowledge of the interactions between society and the natural environment are necessary prerequisites for successful action in the direction of sustainable development. Explanatory knowledge about relevant systems is the knowledge, the production of which – according to the classical concept of science – is the specific object of the sciences. Explanation, whether by means of experimental or observational research, is the primary purpose of the sciences in their traditional self-concept. Corresponding systems knowledge and causal relations then can be used for modelling and simulation (Schellnhuber/Wenzel 1999).
- *Orientation Knowledge*: The appraisal of societal circumstances and developments, of global trends, and of measures requires *orientational criteria* which permit comprehensible and transparent differentiation in “sustainable“ and “non-“ or “less sustainable“. These criteria are normative: they aren’t derived from an observational or experimental occupation with the phenomena, but require a justifying argumentation which operates with normative premises. According to the respective concept of sustainability, various patterns of argumentation come into question. Different assumptions on the substitutability of natural capital (“strong“ vs. “weak“ sustainability) lead to different criteria, as do differences in the normative foundation (for reference to the finite carrying capacity of natural and societal systems versus the justice-theoretical basis, cf. Grunwald/Lingner 2002).
- *Knowledge for Action*: Foresighted knowledge of measures and of their effects is a decisive prerequisite for informed decision-making. Besides the diagnosis function of sciences with regard to sustainable development (which can be provided by the combination of explanatory and orientation knowledge), science‘s primary task is the specifically scientific contribution to the *therapy* of sustainability problems. In the final analysis, science for sustainability aims at coherent and integrative action-guiding knowledge for politics and society. In this sense, science for sustainability produces, as a rule, *strategic knowledge*. Part of this knowledge production consists in revealing transparently the uncertainty and incompleteness of the knowledge produced, and to point out courses of action under uncertainty.

Strategic knowledge for sustainable development consists of necessity of combinations of these three types of knowledge (Grunwald 2004). If it is, finally, a matter of providing knowledge for action for society and politics, if it is a question of supporting knowledge-based decision-making processes, then all of the types of knowledge alluded to are indispensable: explanations of cause/effect chains provide the cognitive basis for every sort of action. Orientational criteria are equally indispensable for diagnosis as for therapy, and in knowledge for action, they combine. Politically and societally usable stocks of knowledge for sustainable development consist of combinations of these types of knowledge.

3. Uncertainties of knowledge in shaping technology for sustainable development

The development, production, use and disposal of technical products and systems have impacts on the ecological, economic and social dimensions of sustainable development and vice versa. Anthropogenically produced or modified material and energy flows represent key factors with respect to the sustainability of human society – both due to the long-term *environmental consequences* and also with regard to *economic* (e.g. availability of resources) and *social* (e.g. health and equity) aspects.

Shaping technologies in favour of sustainable development means that the sustainability assessments of the technologies under consideration have to be performed *in advance* to the relevant decision-making in the course of their development. This requirement implies that *prospective knowledge* on the sustainability effects of the production, use, and disposal of those technologies has to be made available in order to support decision-making. In order to provide such knowledge a good understanding of the dynamics and the future development of the affected subsystems of society and the respective role of technology is necessary. Serious and indispensable uncertainties of that understanding result from (1) the inseparability of influencing factors for sustainability effects among them new technologies are only one element, from (2) the manifold of sustainability aspects which have to be taken into account, from (3) the incommensurability of those aspects, and from (4) the well-known problems related with making predictions. *In the last consequence, uncertainty of knowledge is framed as the uncertainty of knowledge pieces which are relevant for the design, implementation and monitoring of steering measures and processes.*

(1) The inseparability issue: co-evolution of technology and society

In order to make sustainability assessments of the production and use of new technologies it is an essential point that the sustainability effects will only partly be determined by the technology alone. Technology always will be embedded in society, and in the sense of the idea of a co-evolution (Rip 2006) of technology and society it is neither the case that technology determines future aspects of societal development nor that technology can be determined by society according to its intentions. Instead, there will be a process of mutual influencing in each case, involving a lot of different influencing factors.

For the sustainability challenge, this means that in order to assess the sustainability effects of a specific new technology also the changes in societal behaviour according to the process of embedding the respective technology have to be taken into account (Fleischer/Grunwald 2002). A sustainability assessment of technology has to include changes of societal processes, structures, values, customs etc. which might come up in the course of integrating the technology in society. This means that the technology effects on sustainable development also include a – possibly extended – set of societal aspects. Sustainability effects of technology cannot be assessed by only looking at the technology itself, at its features, at the way it will be produced or at resources needed and emissions produced during the time of its usage. Instead, the technology itself is neither sustainable nor unsustainable but only might *contribute to* sustainable development. Whether this contribution will really appear and how it would look like does not depend on the technology alone but also on the societal mechanisms in its context. The complexity of embedding technology into the society, and of the mechanisms of "co-evolution" are leading to an assessment situation where the assessor has to look not only at the technology but also on the affected subsystems of society. Clearly, the inseparability of technology from society will lead to uncertainties of the knowledge provided because of the systemic nature of societal interactions with new technologies, for example by feedback loops and emerging effects by self-organisation (Voss et al. 2006). Such systemic effects (like rebound-effects) could undermine the assumed conditions for the success of a technology as well as the conditions for the positive sustainability effects aimed at to come into reality.

(2) The incompleteness issue: manifold of sustainability aspects

The normative dimension of sustainability shows a lot of different and heterogeneous aspects, reaching from dealing with natural resources up to organising society due to postulates of equity and justice (Kopfmüller et al. 2001; Grunwald 2004; Voss et al. 2006). Many fields have to be observed, and a large number of indicators have been proposed to get a full picture of the empirical societal situation concerning sustainability. However, there cannot be a guarantee that this "full picture" aimed at will really be given. Relevant aspects with regard to sustainability might be simply overseen or might be excluded from further consideration following a (misleading) judgment of low relevance in the respective field. To achieve completeness in the investigation of sustainability aspects of a new technology is impossible for philosophical, economic, and pragmatic reasons (Schröder et al. 2002). Decisions on the relevance or irrelevance of specific dimensions have to made, as well as decisions about the limitations of the systems considered. Such decisions, however, are risky in itself (Grunwald 2003). Whether they have been based on correct judgments often will be clear no earlier than after decision-making, production and use of that technology – but then it might be too late to change something. The risk of incompleteness of knowledge in decisions about the assumed sustainability of new technologies is indispensable, and will generally lead to uncertainties in the process of decision-making and governance.

(3) The incommensurability issue

The same initial conditions – a lot of different and heterogeneous aspects of sustainability, reaching from dealing with natural resources up to organising society due to postulates of equity and justice so that many completely different indicators have to be observed – also lead to a methodically different issue: because of the heterogeneity of the various dimensions and indicators of the sustainability of a technology path or system there is no common sustainability measure available for all of them. It is methodically not satisfactory to measure emissions of greenhouse gases, numbers of people affected by long-term unemployment, information on the cooperation with developing countries or the existence of civil society organisations and engagement by applying the same unique scale of measurement. The various dimensions and indicators of sustainable development cannot be integrated into one single measure like a "sustainability index" of a technological system or product.

This situation also restricts the possibilities to use quantitative methods, and in case some of them like cost/benefit analysis would be used, their results have to be integrated with result from more qualitative argumentation and investigation – which is, in methodical regard, a delicate endeavour. The only exception from this complexity situation might be the case of a pure substitution: substituting an elder technology by a new one where the societal context will not recognize this substitution at all. In this case the "objective" features of the technology like resource productivity or emissions could be compared, assuming that *ceteris paribus* conditions hold for all the other sustainability aspects.

This "incommensurability issue" does not affect usual disciplinary pieces of knowledge but leads to specific uncertainties of *integrated* knowledge. Especially the case might occur that both positive and negative contributions to sustainable development could arise from the same technology but with respect to different sustainability indicators or aspects. If in this case there is no chance to integrate the diverging results into a quantitative bilance and to decide then which contribution is the dominant one, the assessment exercise will be left to careful and qualitative consideration as well as to complex processes of weighing arguments and defining priorities.

(4) The prediction issue

All of the before-mentioned issues suffer from a further complication in the case of future projections – and, as has been said, future projections are necessary to make sustainability assessments in advance to decisions about technology design and development. Shaping technologies for sustainable development requires anticipatory sustainability assessments in order to allow distinctions between more or less “sustainable” technologies (Fleischer/Grunwald 2002). Such anticipatory assessments are concerning the production phase, the usage phase and the disposal of technical products and systems. They have to cover the entire *life cycle* of a technological product or system. The life cycle starts with exploring and mining natural resources and raw materials, leads via transport and various treatment processes to the fabrication areas where components of a system are produced, extends to the – intended and possibly non-intended – usage of the technology in society, the impacts and consequences of the usage for the natural environment but also for society, and finally must take into account the disposal of technology products. Sustainability assessments of technology consist of a temporal integration and bilance of any sustainability effects which might occur during the complete life cycle including production, usage and disposal.

Because sustainability assessments of new technologies shall contribute to shaping the technologies and therefore must be performed in early stages of the development (Fleischer/Grunwald 2002) the life cycle of new technologies lies in the future seen form the standpoint of designers and decision-makers seeking orientation towards sustainable development. That means that prospective life cycle analyses are to be burdened with a large prediction load: consumer and production patterns, future developments of lifestyles and markets, political and economic boundary conditions for the later usage of new technologies are only some examples for aspects of the future which should be known in advance in order to perform reliable life cycle analyses for supporting sustainability assessments.

High expectations concerning the possibilities of reliable far-ranging predictions, however, have been disappointed for many times. Many reasons have been identified against the predictability of societal issues (Grunwald/Langenbach 1999) and of the development of complex socio-ecological systems. Instead of making predictions the Technology Assessment community moved to regard the future as an open space which could only be addressed and structured in the form of "possible futures" like scenarios (Grunwald 2002). Taking this point – unavoidable uncertainties of *predictive statements*, independent from whether they are concerning societal states, processes or the effects of steering measures towards sustainable development – seriously changes dramatically the scheme for steering: while in classical steering regimes predictions are used for describing the (assumingly fixed) boundaries within which the steering intentions had to be approached in a most efficient way it comes out that no or only few such boundary conditions exist in the field of steering for sustainability.

A fortiori, assuming that certain sustainability measures would be implemented against the background of some assumptions about future developments and about the intended effects of the measures, it might even be the case that the implementation of the measures could challenge the conditions which had been regarded as relevant for the success of the measures. It comes out that there is a further inseparability which seems to be at the heart of the challenge of steering for sustainable development: the actors and decision-makers cannot separate some unaffected boundary conditions – which might be predicted – from the fields they want to influence and to shape by applying certain sustainability measures. There is no observer's standpoint available from which such a separation could be done. All of the actors are – of course, in different roles – *participants* in a common transformation process.

Conclusions

Consequently, sustainability assessments can only be made under the condition of uncertainty and incompleteness of knowledge. As a consequence, the notion "sustainability potentials" of innovative technologies is currently widely being used. This notion seems, at the first glance, to avoid all problems of predicted and promised sustainability effects of new technology developments. However, there are at least two severe problems:

a) It would be hard to imagine a technology for which no sustainability potentials at all could be identified. But: potentials are *mere potentials* – which means that neither there is an automatism that they will become reality at any time nor there is a clear statement on the probability of becoming reality or on conditions for becoming reality. Talking about potentials is nothing else than to give a promise. Further knowledge (a certain type of orientational knowledge, see above) would be needed in order to enable decision-makers to assess the validity of the promises.

b) It should not be forgotten that – besides the positive potentials of new technologies for sustainable development – there also might be *negative* effects. These are also hypothetically but as soon as positive potentials are used as a replacement for a sustainability assessment the possible negative effects should also be taken into account in favour of a comprehensive and balanced picture – even if also this picture remains uncertain.

Independent from the approach and the notions chosen it results from the uncertainty issue that it is not possible to foresee the sustainability effects of a technology in the development phase in a complete and certain way. Uncertainties remain. This situation requires an adaptive approach for shaping technologies for sustainable development, including a permanent monitoring of new knowledge available and the agreement of integrating new knowledge and new orientations even in the later phases of development – which, of course, often is difficult maybe impossible.

4. Uncertainties of knowledge – steps of further analysis

The issues which have been presented for the case of shaping technology for sustainable development point, more or less, to more general characteristics of approaching sustainability by steering measures. The *inseparability issue* is relevant for each governance activity towards sustainable development. In the prospective assessment of consequences and impacts of the implementation of measures not only the field which shall be influenced has to be considered but also other, possibly affected fields. A comprehensive sustainability assessment of measures must not be restricted to separated pieces of society. In the case that such a restriction has to be made for pragmatic reasons (which is usually the case) then the export/import effects at the border of the system considered have to be carefully investigated (Coenen/Grunwald 2003). The *incompleteness issue* may be transferred to more general shaping activities without any change of its meaning. This also holds for the *incommensurability issue* and for the *prediction issue.*

In order to get a better imagination how to deal with these issues related to uncertainty of knowledge it seems to be appropriate to go deeper into some aspects of uncertainty and its relation to sustainability governance.

(1) Origins of uncertainty

There are different origins of the uncertainty of knowledge pieces relevant to sustainability governance. As I can see in the moment, there are the following types of origins:

- incompleteness of the present knowledge about systems dynamics in various field, especially in combined systems nature/society;
- inseparability of sectoral developments from the development as a whole with the consequence that import/export relations have to be considered – resulting in much higher complexity and need for knowledge integration with its own uncertainties;
- much more possibilities of recombination of particular effects, of spreading uncertainties through the whole knowledge system, of unforeseeable combination effects of different uncertainties, and of the emergence of unexpected system effects;
- the necessity of grounding steering activities for sustainability on expected future developments, and on expected outcomes of the measures in rela-

tion to these developments, bring the entire field of uncertainties of future knowledge into the game;

- the fact, that future developments in society and at the interface between society and the environment depend on present and future decisions, e.g. about the political boundary conditions but also on consumers behaviour and production patterns, implies that *assumptions* about those decisions have to enter the future projections.

These various origins of uncertainty are different in nature and will need different ways of dealing with them. Some of them are indispensable while others might, at least partly, be overcome by improved methods and models.

(2) Different degrees of uncertainty

The authors of the key note paper of this workshop (Voss et al. 2006) put emphasis on the fact that uncertainties have to be differentiated in terms of their degree of uncertainty. I would like to go a step further and postulate that what is missing still is an "epistemology" of uncertain knowledge. Philosophy of science invested a lot of work into the epistemology of knowledge under the claim of certainty or even truth. The issue of uncertainty, however, has been dealt with only in few cases (for example, in some contributions to Gottschalk-Mazouz/Mazouz 2003).

This task seems to be more complicated than expected at the first glance. It should rely on an analysis of knowledge pieces which enter the knowledge needed to design and to implement sustainability measures with respect to their claim of validity (Geltungsanspruch) and the possibilities to realise that claim by argumentation. Some questions are:

- what can be said about the pieces of disciplinary knowledge involved, compared to the usual disciplinary standards of scientific knowledge?
- in which way can the *extrapolation* of such knowledge pieces – which are always *present* knowledge – to the future be argued for? Where are the counterarguments and in which way can they be weighed against each other?
- in which way do the projected developments depend on future societal decision-making?

The aim should be – but this would go far beyond the scope of the keynote lecture and of the governance workshop – to establish a typology of knowledge types with different degrees (and origins) of uncertainty.

(3) On the relation between steering actors and steered systems

A very deep distinction can be found in most approaches to scientific modelling and simulation of systems relevant to sustainability. This is the distinction between the system to be influenced by steering measure and the actors who are responsible for the implementation. In this sense (Voss et al. 2006, S. 8f.): "… with respect to the dynamics of the system with which one interacts in implementing steering strategies". It is the basic assumption that the observer of a system may be decoupled from the observed system which has been the classical epistemological situation in science. The question, however, is whether this basic distinction still holds for such complex issues like steering for sustainable development.

There is one indicator that this will not be the case in general. In using predictions and future projections for orientating sustainability measures we sometimes can observe issues like self-fulfilling or self-destroying prophecies. These phenomena result from the situation that the predictive statements made are not simply results of observations but at the same time change the boundary conditions for societal groups and actors. In this may, the predictions modify the conditions which have been assumed to be valid during establishing the prediction. The predictor in these situations is not a distant observer but simultaneously a participant in ongoing communication who might – by his or her observations and the resulting predictions – change the acting conditions for other people. Here wee see that the distinction between a distant observer who does not intervene and the system to be observed and steered does not work.

In the context of steering for sustainability there is an epistemological question behind this: under which conditions does the classical distinction between an observer and the observed system work? In cases we would answer the question with "no" there should be specific ways of dealing with uncertainties. It might come to paradox situations where attempts to reduce uncertainty would lead to an increase of uncertainty.

(4) Uncertainty as chance?

Frequently, the issue of uncertainty is being discussed in a modus or attitude of "lamenting": the uncertainty of knowledge would endanger designing and implementing promising sustainability measures, it would disturb steering activities towards sustainable development, it could even be misused by politicians as an argument for a "wait and see" strategy: if the knowledge is uncertain, some of them say, then we should wait until science has made its homework and will then be able to provide certain and valid knowledge so that steering towards sustainable development could be shaped as a type of engineering. Also scientists often approach uncertainty as something which should be overcome. Two remarks in this respect:

- Uncertainties will remain in spite of the scientific effort to overcome it. There is no way to gain certain knowledge about future developments. Of course we should do whatever is possible to decrease uncertainty but should accept that there are limitations;
- Perhaps we should take a point of view different from the "lamenting" perspective and could try to regard uncertainty as *chance*. Please imagine the case that uncertainty could be erased completely: the future would be completely determined already in the present. To give exact and correct predictions implies that the future is already determined. There would be no open space for thinking, problem-solving, planning and shaping. Uncertainty – though its negative connotations of having no certain knowledge – is the other side of the coin of on open future. It allows for learning processes, for

steering according to self-defined goals, for deliberating about how to shape the future, for pro-actively thinking about the future society.

Therefore, uncertainty is nothing which could or should be eliminated completely. It comprises not only risks for steering activities but simultaneously opens up spaces for reflection, learning, and open deliberation.

5. Uncertain knowledge and steering action

5.1 Evidence thresholds to motivate action

A frequently discussed question is, whether and to what extent the knowledge currently available is sufficient to legitimize sustainability-relevant action, for instance, in view of societal costs connected with it. In the electro-smog discussion, it is disputed whether our present basis of knowledge justifies assumptions of detrimental effects of electromagnetic radiation on human beings: one doesn’t know enough to be able to act; one doesn’t even know enough to be able to judge whether we have to act at all (Revermann 2003). In the climate change debate as well, the question for the applicability of the precautionary principle (Schomberg 2005) and for its consequences is the fundamental question (Schröder et al. 2002).

The demand for completeness with regard to the knowledge basis, or the demand for guaranteed certain knowledge can paralyze action or even be (mis-)used to delay or prevent sustainability-relevant measures: as long as the way the systems work isn’t completely and certainly known – as is voiced in an occasionally heard opinion –, one can’t decide on the necessity nor on the aptness of measures. This position would take the uncertainty and incompleteness of knowledge as an argument to do nothing – which, in many questions, could lead into the risk of waiting too long: it could be too late to prevent catastrophes or irreversible unsustainable developments when secure knowledge would be available.

Of course, this precautionary strategy must not be overstressed. A certain “evidence threshold” must certainly be exceeded, if drastic measures are to be justified. Not every mere suspicion (for instance, in the sense of a “heuristics of fear” or of a “primacy of the negative prognosis“, Jonas 1979) may lead to massive political and societal regulatory measures; this would cause a complete blockade. In order that the precautionary principle can become effective – and sustainability is inseparably bound to precaution –, a potential hazard has to be proven comprehensibly. The many debates on how to identify a balanced way in applying the precautionary principle and in analysing its impacts have their epistemological, ethical and ethical origin in the difficulties to deal with the uncertainty, incompleteness, or even the absence of knowledge.

5.2 The interdependence of knowledge and judgements

In addition to the provisional nature of knowledge and values, one has to take the fact into consideration that both of these are – through their provisionality – correlated with one another. The results of judgements depend not only on normative evaluative criteria, but also on the state of knowledge. Evaluations don’t merely refer to values, but combine values with knowledge. Judgements are, in this manner, connected with the problems of knowledge under conditions of uncertainty and incompleteness. New knowledge might lead to modified assessments of societal developments or of technology from the viewpoint of sustainability. Two simple examples: the perception of asbestos as a building material changed radically as soon as its cancerogenic effects became known, just as the public opinion on the CFC's (chlorofluorocarbons) changed after the discovery of the ozone hole (on these case studies, cf. Harremoes et al. 2002).

Conversely, assessments have considerable influence on the question, which knowledge is held to be urgently needed. Evaluations influence the formulation of research programs and the allocation of societal resources. Assessments make themselves felt even in the design of projects for sustainability research: the exact definition of the problem to be investigated, the delimitation of the system, the decision, which system effects should be included in the modelling and which not – all these decisions concern non-scientific considerations of relevance, and have, as such, considerable influence on the question, which knowledge should at all be produced (s. above).

5.3 The experimental nature of sustainability policies

The uncertainty and incompleteness of knowledge (and the provisionality of evaluations) make a complete implementation of sustainability in the sense of a detailed planning in the direction of sustainability impossible. It becomes obvious with all clarity that a policy of sustainability has to be carried out under conditions of uncertain knowledge and of provisional assessments. A policy of sustainability is therefore confronted with the limits of the availability of knowledge. It is *ex ante* not stringently decidable, whether and to what extent a political measure, a technological innovation, or a new institutional arrangement will, in actual application, "really" contribute to sustainability. Every sustainability policy has to face this situation and become – in a certain sense – "experimental".

This by no means implies the adoption of the evolutionistic principle of trial and error: an experimenter undertakes, as a rule, not just any *ad hoc*-experiments, but constructs well-considered arrangements of technical apparatus, methodical procedures, and observational measures, through the combination of which certain questions are to be answered. Experiments in physics, for example, are developed in careful planning; in measurement campaigns for climate research, or in large-scale experiments in elementary particle physics, this is probably most evident. In spite of all planning, however, the results of the experiments are not anticipatable: experiments have an uncertain outcome, even when there will be more or less good prognostications regarding the result. In the same sense, measures in the scope of a policy of sustainability are experimental: they are *ex ante* carefully plannable by taking scientific knowledge into consideration; their results and effects on sustainability, however, can neither be predicted with certainty nor determined.

For a purposive sustainability policy, it is decisive that, in this experimental situation, the uncertainty and incompleteness of knowledge don't paralyze or hinder action, but that, in the interpretation and implementation of practical measures, a maximum range of opportunities for *learning* in these “experiments“ is seized. In a certain sense, the implementation of measures remains – in spite of excellent ex ante assessments – “experimental”, with the consequence of carefully monitoring the upcoming real effects and to be prepared to eventually modify or replace the implemented measures. In this way, there is an “incremental” way to the future, allowing for learning during the series of the different incremental steps – evaluated always against the normative sustainability framework which safeguards the “direction” of the process. The practical application of political measures *over a certain span of time* therefore offers an essential opportunity for gaining the knowledge which wasn’t available in the planning and preparatory phases, in order to be able to modify and optimize the measures accordingly. The task of empirical research is, therefore, to observe the measures’ effects (monitoring).

Contributions of scientific research to these learning processes in the context of the implementation of political sustainability measures consist, to put it allegorically and remain in the metaphor of the experiment, in first ensuring as good a preparation of the experiment as possible (by analyses of the situation, by causal analyses, by modelling and simulation of proposed measures, etc.), in supervising the careful execution of the experiment, and then in observing the results of the process, in comparing them with the goals pursued, and, if necessary, investigating the reasons for deviations. Classical learning cycles are the result. It is, furthermore, decisive for a successful sustainability policy that the results of these learning processes have consequences for future practice.

6. Conclusions: towards a reflexive sustainability policy

The situation described in the previous section implies a considerable increase in the demands on reflexivity in the sustainability sciences as well as in policymaking for sustainability. Two different levels of knowledge can be distinguished, but both have to be taken into consideration. If strategic knowledge for sustainable development, understood as a combination of explanatory, orientation, and action-guiding knowledge, is classified as knowledge of the first order, then knowledge of the second order consists of knowledge of the *conditions for the validity* of knowledge of the first order. Normative premises, cognitive presuppositions, the limits of the system observed, judgements of relevance made, and awareness of the epistemological limitations of knowledge of the first order belong in this category, as does knowledge of the inherent uncertainties. In addition to the strategic knowledge for sustainable development produced by science, a *meta*-knowledge must therefore be provided, in which the results of science-theoretical and epistemological reflection are included. Society and policymakers not only have to be provided with action-guiding knowledge, but also with cognizance of the manner in which this knowledge is to be interpreted, and where the limits of this knowledge lie.

Science provides, in view of the provisional nature and the uncertainty of sustainability-relevant knowledge, *strategic knowledge for an experimental sustainability policy*. This knowledge has, in case it should actually be implemented, influence on societal practice, which then, in its turn, becomes a subject of scientific research, the results of which, again, should enter into continuing measures. Sustainability policy is, therefore, no matter of simply implementing or applying scientific knowledge, but rather of establishing a learning cycle, which comprises elements of normative premises, political stipulations, empirical analyses with regard to monitoring, and theoretical investigations (as frequently is used in Technology Assessment and Foresight). In order that this can succeed, the relationship between science and politics has to be made capable of resonance (on this point, cf. the sustainability rule on response capacity, Kopfmüller et al. 2001, Chap. 6.6). Societal knowledge management will become particularly important for sustainability policy. Learning cycles of the type mentioned take the specific function of scientific knowledge, but, at the same time, also the special conditions of operating in an area of great uncertainty of knowledge and of evaluation into consideration. Reflexivity is required to provide meta-knowledge about the uncertainties and premises of the sustainability knowledge.

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