Sustainable Development as a challenge for transforming the energy system

Armin Grunwald and Jürgen Kopfmüller

Institut for Technology Assessment and Systems Analysis (ITAS), Forschungszentrum Karlsruhe

Address: P.O. box 36 40, 76021 Karlsruhe, Germany

fon: (+49) 7247 82 2500

fax: (+49) 7247 82 4806

e-mail: grunwald@itas.fzk.de

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Abstract

The energy system (supply, transport and usage) is of highest importance in the context of sustainable development. Main sustainability problems are related to ensuring future energy supply facing globally growing demand but regarding limited natural resources, to emissions against the background of environmental pollution and climate change, to risks to human health and life related with specific energy technologies, and to the problem of equity facing the extremely unequal access to regular energy supply in different parts of the World. In this contribution we will, at first, point to different perspectives on what sustainability could or should mean in the field of energy. This situation will, at second, be interpreted using the notion of sustainability conflicts which, thirdly, marks clearly the need for a closer look at and for clarifications of the conceptual side of sustainable development. The integrative concept of sustainable development introduced in this respect then allows, fourthly, deriving guiding principles for transforming the energy system. Fifthly, we will mention some methodical problems related to providing the knowledge required for implementing an adequate strategy mix. Finally, some conclusions for framing the field will be given.

1. Deficits and problems of the energy system – the challenge

There are a lot of analyses of existing deficits of the energy system concerning sustainability requirements available (see, for example, *UNDP* 1998; *UNDP/SEI/UNCSD* 1997; *UN-ECOSOC* 2000; *Weltbank* 2000; *UBA* 1997). In this paper, we will not aim at providing a new analysis of sustainability deficits. Instead, we will concentrate on the observation that analyses of and perspectives on sustainability deficits of the global energy system are very different with respect to normative backgrounds, diagnoses and the identification of priorities. In some cases, the perspectives are directly conflicting and incompatible to each other

though referring to the same Leitbild of sustainable development. The situation even becomes worse at the level of measures (actions strategies involving specific technologies) proposed. There is no "one-way" situation in transforming the energy system towards sustainable development but there seem to be a lot of possibilities, paths, roads and options which often are being discussed controversially. The main purpose of this paper is to create awareness about the conceptual challenges which have to be met in order to use the Leitbild as guiding principle for transforming the energy system. There is a lot of work to be done to clarify what we are talking about in this field, why we are talking about specific issues, which arguments are put forward to support the specific assessments, diagnoses, proposals and judgments, and which power and validity those arguments could have in conflicts about sustainability issues in the energy field.

In order to support the basic observation of very heterogeneous and partially diverging perspectives on the sustainability transition on the energy system some quotes shall be given and interpreted for illustrative purposes. Having in mind the European debate of the last months, including the G8 meeting at Heiligendamm and strategy-building in the European Union it seems that sustainability of the energy system primarily should mean addressing climate change by reduction of greenhouse gas emission. However, let us look first at some other documents at the global level. Basis for many plans and activities concerning sustainable development is the Johannesburg Plan of Implementation (JPOI), adopted at the World Summit on Sustainable Development in 2002 which also addresses the energy field. The JPOI calls for action to:

- improve access to reliable, affordable, economically viable, socially acceptable and environmentally sound energy services
- recognize that energy services have positive impacts on poverty eradication and the improvement of standards of living
- develop and disseminate alternative energy technologies with the aim of giving a greater share of the energy mix to renewable energy and, with a sense of urgency, substantially increase the global share of renewable energy sources
- diversify energy supply by developing advanced, cleaner, more efficient and cost-effective energy technologies
- combine a range of energy technologies, including advanced and cleaner fossil fuel technologies, to meet the growing need for energy services
- accelerate the development, dissemination and deployment of affordable and cleaner energy efficiency and energy conservation technologies
- take action, where appropriate, to phase out subsidies in this area that inhibit sustainable development

While the challenge of transforming the energy system towards sustainable development is currently understood in Germany and in many parts of Europe primarily in the context of the climate change debate this word does, on the one hand, not appear at all in these calls for action. On the other, some frequently used notions used like "poverty eradication" do not have a place in the European debate. This divergence of different perspectives shows itself even more radically in a recent statement of the United Nations (UN 2005, p.2) which refers also to the JPOI: "Currently, the available energy services fail to meet the needs of the poor. Worldwide, 2.4 billion people rely on traditional biomass for cooking and 1.6 billion people do not have access to electricity. This situation entrenches poverty, constrains the delivery of social services,

limits opportunities for women, and erodes environmental sustainability at the local, national and global levels". The main messages which were derived from this diagnosis are:

- Energy services such as lighting, heating, cooking, motive power, mechanical power, transport and communications are essential for socio-economic development, since they yield social benefits and support income and employment generation.
- The poor obtain energy services by gaining access to modern fuels, electricity and mechanical power. The access is particularly important for women and girls since they are often the most affected by inadequate energy services.
- Reforms to the energy sector should protect the poor, especially the 1.1 billion people who live on less than $1 per day, and take gender inequalities into account in recognising that the majority of the poor are women.
- The environmental sustainability of energy supply and consumption should be enhanced to reduce environmental and health hazards. This requires measures that increase energy efficiency, introduce modern technologies for energy production and use, substituting cleaner fuels for polluting fuels, and introduce renewable energy.
- Large amounts of financial resources need to be mobilized for expanding energy investments and services in developing countries. They account for a much higher share of gross domestic product compared to OECD countries. Public sector resources will remain crucial for investing in energy service delivery for the poor due to the private sector's limited appetite for risk in emerging market.
- The role of energy and the costs of energy services should be factored into overall national economic and social development strategies, including poverty reduction strategies and MDG campaigns, as well as to donor programmes in order to reach development goals. Energy planning must be linked to goals and priorities in other sectors.

For the European auditorium this list and the inherent priorities may sound rather strange. Most Europeans will not be used to relate sustainable development and energy *primarily* via poverty reduction and gender issues, and many will feel uncomfortable with the fact that environmental concerns are not really highlighted in that paper and that climate change is not mentioned directly.

Let us look at another arena in the large energy field. A completely different picture compared to the presented UN perspective can be found in the current debates on the future of nuclear power. Organisations and people promoting nuclear power also like to argue in terms of sustainable development (Google provides a lot of hints, for example see http://www.iaea.org/Publications/Booklets/Development/devtwo.html). The nuclear lobby, some politicians and scientists claims that nuclear energy should be regarded as essential part of a sustainable energy system (???). Main arguments are the absence of climate relevant CO2 emissions during the energy-providing process in nuclear power plants resulting in positive effects concerning climate change compared to coal or natural gas used for electricity supply, and the fact that uranium resources are widely distributed worldwide which prevents monopoly situations like and geo-political dependencies like in the field of fossil oil. The problem of poverty reduction which has been highlighted in the UN documents seems to be infinitely far away. Other parties in the nuclear conflicts (environmental movements, NGOs) highlight the inherent risks of nuclear power, the problem of radioactive waste and the dangers of proliferation – again completely different fields of argumentation.

What we can learn from briefly looking at this very heterogeneous field of sustainability diagnoses and expectations concerning the energy challenge is that there are four dimensions of sustainability problems and goals as well which can be distinguished by different argumentation patterns behind them (Kopfmüller et al. 2000):

- *Limited energy resources*: non-renewable energy resources, especially the fossil resources, are of strictly limited availability in the natural environment. There are controversies about the temporal range of, for example, oil and natural gas, but no doubt that these resources are limited. Consuming parts of them implies the reduction of the remaining resources. Also the availability of many renewable resources is limited. For example, the energetic use of biomass is limited by the amount of agricultural areas which may be used for energetic purposes without endangering the food production. These limitations will become more relevant and serious because of the strongly increasing energy demand at the global level. Scarcity of energy means increasing prices and decreasing chances of developing countries to catch up.
- *Emissions*: Main parts of environmental pollution are caused by energy supply technologies. The issue of greenhouse gases contributing to climate change is the currently dominating factor in the European debate on a more sustainable energy system. In developing countries, especially in larger cities and in mega-cities, the problem of local air pollution endangers health of the inhabitants. Also indoor air pollution is frequently a problem, caused by cooking and heating using traditional biomass.
- *Technological risks*: the energy system includes many technologies of energy transformation, transport and use which show risks of accidents and failure causing environmental and health problems, or which might be subject of terrorist or war attacks.
- *Problems of access:* Today's developing countries, with some three quarters of the world's inhabitants, consume only one fourth of global energy. Current annual per capita energy consumption differs markedly by country and region. The United States of America show a per capita consumption close to 20 tonnes of oil equivalent (toe), which is about fifteen times greater than Brazil, where consumption is again fifteen times more than in the United Republic of Tanzania or in Bangladesh. This situation is problematic concerning the imperatives of justice and equity of access (see chapter 3 of this paper) but also because the availability of energy is of highest importance for the further development of poor countries (see above). There seems to be a dead-lock-situation: energy is worst-available in those areas of the world where energy for development is most-urgently needed.

This brief look at the current debate and on recent documents at the interface between sustainable development and the energy sector shows very clearly that there is neither a well-clarified understanding of what sustainability would imply for transformations of the energy system nor a common understanding about the priorities in this field. Furthermore, there are harsh controversies and unsolved questions of the type:

- How can innovations in the energy system into the direction of sustainable development be promoted?
- What are adequate measures and how could or should the roles of states, NGOs, companies, consumers, supra-national organisations and others be co-ordinated to this end?

- What role could or should nuclear power play in an energy system committed to sustainable development?
- Are renewable energies sustainable anyway or are there stricter requirements for sustainability? What is, for example, to say about conflicts concerning wind power plants among the regional population which sees traditional landscapes in danger?
- Is the CCS (Carbon Capture and Sequestration) a "sustainable" way of dealing with CO2 from fossil energy carriers, and which side-effects and risks have to be taken into account?
- What role should be attributed to climate change in defining priorities? And what would follow from specific positions concerning this issue?
- What can be said about long-term developments, for example regarding the global potentials and limitations of an "efficiency revolution"?
- A lot of ideas, expectations, fears and hopes, visions, scenarios, strategy recommendations are on the table. How should be arrive at a "rational" assessment - and what would be the meaning of "rational" in this respect?

There are a lot of conflicts, controversies or more implicit ambiguities virulent in this field. This is sufficient motivation to undertake a closer look at the more general role of conflicts around sustainable development.

2. Conflicts around Sustainable Development

Sustainability as a societal vision is, on the one hand – at least on the political-programmatic level – not only potentially acceptable, but does, in fact, meet with correspondingly broad approval across all societal groups and political positions, nationally and internationally. The number of nations which have signed and ratified the documents of Rio 1992 and the corresponding follow-up papers and the numerous local or regional activities are impressive. On the other hand, the question has to be raised how far the consensus at the programmatic level reaches in concrete decision-making. As has been illustrated above in the field of energy sustainability's conflict potential can't be overlooked, and consequently any optimism concerning a common understanding of what should be understood by a "sustainable energy system" and what should be done in order to approach it should be strictly limited. As soon as relatively concrete goals or even strategies of societal action for attaining sustainability in the field of energy are put on the agenda – at the latest – it becomes obvious that antagonistic societal values and interests are lurking behind the programmatic consensus as well as different perspectives on the field and different priorities in identifying the most urgent fields of action.

The presence of conflicts over sustainability, the possibility to set different priorities, and the observable controversies seem to support the opinion that sustainability is a concept without content, or that sustainability is merely a harmonistic wrapper over heterogeneous and incompatible goals, and can therefore only have rhetorical functions – what would be a catastrophic statement as far as sustainable development shall guide the transformation of the energy system. It has sunken, so some people argue, to the level of arbitrariness, and no longer has any power to "make a difference". The objection that nothing more than harmonistic meaninglessness is hidden behind the concept of sustainability, that talking about sustainabil-

ity would therefore either be of no consequence, or could be arbitrarily instrumentalized or misused, can be interpreted in a number of ways which allow a better understanding of that objection:

- *Sustainability as mere design*: The postulate of sustainability has, in this version of the objection, no content. Of course, nobody can be opposed to a person's pursuing his or her economic interests in a sustainable manner which "satisfies the needs of the present generation without compromising the ability of future generations to satisfy their own needs" (WCED 1987), but acceptance of this understanding says nothing specific regarding content. People who can all generally agree with this statement can still compete further for diametrically opposed aims.
- *Sustainability as an ideological illusion*: The concept of sustainability conceals in this manner the conflicts of interests among the real actors and the actual power constellations. It is instrumentalized as an ostensible legitimisation of power and of particular vested interests, for instance, in the question of the relationship between securing continued affluence in the industrialized nations and the perspectives for the developing countries. The danger is that each social actor or group may define its "own" sustainability – the farmers, the industry, social movements, political parties, authorities or others. All of them could then claim to promote sustainable development but with using diverging or contradictory understandings of sustainability.
- *Sustainability as a utopian hope*: A further point of critique is that the concept of sustainability might be overtaxed (Knaus/Renn 1989). If sustainability should be used as a collective designation for everything "noble, helpful, and good", then this would be impracticable, could lead to arbitrary conclusions, and would arouse expectations which can't be fulfilled. The concept of sustainability as an integrative-utopian aspiration is, according to this contention, a harmonistic illusion which blocks the view onto the real problems.

Before reacting to these suspicions and criticisms a closer look on the nature of sustainability conflicts shall be given. Conflicts over sustainability don't first arise at the point when concrete measures are discussed. Rather conflicts are unavoidable as early as on the conceptual level where the basic understanding of sustainable development has to be clarified (as can be seen from the brief illustration above). The following types of conflict can be distinguished:

- *Conflicts about the scope of sustainability in normative respect and inherent hierarchies*: What belongs to the subject area that the principle of sustainability should be applied to, and what doesn't? Is it solely a matter of responsibility for the future (which would prefer the priority of climate change issues and resources issues) or of distributive justice in the present (which would prefer the reduction of poverty as most urgent issue)? Is sustainability a question of conservation, or of development – or of both? The determination of the normative scope is obviously connected with societal conflicts, because values enter the field as is also the case in balancing arguments of different origin. Whenever it is a question of the mutual relations of the various (ecological, economic, social, and political) dimensions of sustainability, or of the relation between inter- and intragenerational equity, careful consideration and weighing of priorities are imperative. The proposed approaches to sustainability in the various dimensions will not always mutually reinforce each other and lead to "win-win"-situations. For instance, the precept of conserving landscapes of a particularly characteristic nature and beauty can come into conflict with the need for more renewable energy supply by wind power. It is then necessary to weigh up goals and values and to set priorities which, as a

rule, quite obviously give rise to societal conflicts – and which is related to the internal normative hierarchy of sustainability, for example the question of conservation and/or development.

- *Conflicts about weak or strong sustainability*: Every generation disposes over a certain productive potential, which is made up of various factors (natural capital including energy resources, real capital, human capital, knowledge capital). Sustainable development demands in general, that the stock of capital which exists within a generation be handed down as undiminished as possible to future generations – whereby, however, two fundamentally different alternatives are conceivable. On the one hand, one could stipulate that the sum of natural and human-made capital be constant in the sense of an economy-wide total; on the other hand, one could require that every single component of itself has to be preserved intact. The former path is sensible if one assumes that natural and human-made parts of the overall capital are completely interchangeable (weak sustainability). The latter path is advisable if one assumes that human-made and natural capital stand in a complementary relationship to one another (strong sustainability).
- *Conflicts of Distribution*: Conflicts of distribution are among the most virulent sustainability conflicts at the political level. They comprehend the distribution of using limited natural resources, the distribution of using the natural environment as a sink, the distribution of obligations to act in favour of sustainable development (for example, by greenhouse gas mitigation) and the distribution of loads of sustainability measures among states or societal groups. On the one hand, conflicts of distribution arise because of the winner-looser problems, and on the other hand, due to the finiteness of scarce resources, such as fossil energies and agricultural areas. Conflict potentials can arise especially on the strategic level when it comes to translating the principle of sustainable development into concrete responsibilities of action for societal actors. When, for example, one has to decide which contribution the transportation industry and which the energy suppliers should bring toward realizing a national CO_2-reduction target.

Conflicts over sustainability, therefore, do not only occur, as is often discussed, on the strategic level of concrete measures and their realization, but are inherent in the very conceptualization of sustainability. The different types of sustainability conflicts mentioned have their origin in the diversity of the conflicts inherent in a pluralistic society (as, for example, differing conceptions of justice, of responsibility, of the role of the welfare state, or of the economic system). Different and contradicting interests between social actors, between NGOs and industry, between political parties or between developed and developing countries are leading to such conflicts. This is in no way surprising.

Not only already existing societal conflicts play a role, but the imperative of sustainability is also the source of *additional* conflicts. As soon as the question of justice – and this is the essence of sustainability – is extended beyond the small national or regional circle of the present generation to the global scale and to future generations, completely new questions and additional distributive problems arise – with the corresponding lines of conflict. In this category belong questions of the sort, whether and how much abstinence can be expected of those presently living (in the Western nations) in the interest of future generations, and if so, how this abstinence should be distributed among and within nations. This situation is the clearest proof of the fact that the principle of sustainability is anything but harmonistic, and can even be the *origin* of conflicts.

It is the extension of the time and space dimension inherent to the imperative of sustainable development which leads to new types of challenges in the reflections on justice and equity. Conflicts between the assumed needs and interests of future generations – obviously, there is already a problem of knowing enough about them – and the interests of people living today arise. Why should we renounce on realising our needs in favour of future generations which we will never meet? The global dimension of sustainability (Kopfmüller et al. 2001) leads to a more narrow contact of different traditions and cultures in attempting to arrive at a common understanding of sustainable development. Different concepts of nature, different views of the relationship between the individual and society, different religious and cultural traditions, different conceptions of justice enter into the sustainability conflicts. Solutions in this respect will require identifying the explicit and implicit contradictions and divergences between different cultures in the fields of conflict mentioned above and dealing with them in a constructive way.

3. Sustainable Development – a closer look

Since the report of the Brundtland-Commission (1987), much has been said about sustainability. There are roughly 60 definitions of sustainable development and various concepts for its implementation as well (Jörissen et al. 2001). There is considerable need for orientation knowledge on the manner in which the concept of sustainable development can be filled with substance in a relatively conclusive and integrable manner – a crucial need as soon as the Leitbild of sustainability is expected to guide the transformation of the energy system. A fundamental requirement is that the term "sustainability" has to have the *power of differentiation*. Terms are coined in order to distinguish something from something else. An understanding of sustainable development which lays claim to practical relevance and to contribute to solving societal problems is a challenge to scientific conceptual work to clarify the term "sustainable development" in such a manner that at least the following criteria are fulfilled:

(1) Object Relation: From the definition of sustainable development, it must follow what the term applies to and to what not; which are the objects to which attributes such as "sustainable", "non-sustainable" or "less sustainable" should be ascribed?

(2) Make a difference: Within the domain, comprehensible and unequivocal differentiations between "sustainable" and "non-" (or "less") "sustainable" have to be possible. Concrete ascriptions of these judgements ("sustainable"/"non-sustainable") to societal circumstances or developments have to be made possible beyond arbitrariness.

(3) Operationalizability:; the definition has to be substantial enough to permit the formulation of targets for sustainability indicators and to allow for empirical "measurements" of sustainability.

The well-known definition formulated by the Brundtland Commission, according to which development is sustainable when it "meets the needs of the present generation without compromising the ability of future generations to meet their own needs", the Commission's explanatory texts, and other central documents of the sustainability discussion, such as the Rio Declaration, have been used as points of departure to identify the following constitutive elements of sustainability (for details, see Kopfmüller et al. 2001, Chap. 4):

- Justice: Sustainability and justice are inseparably interwoven. In particular, inter- and intragenerational aspects of equity are both equally constitutive for sustainability.

- The Planetary Scope: The global perspective and problems of global scope are the points of departure for defining criteria for sustainability.
- Anthropocentrism: Anthropocentric premises have from the beginning been inherent in the sustainability discussion, because sustainability is a question of the human use of resources.

On this basis, the following super-ordinate goals of sustainability can be formulated, which take a first step in the direction of concretization (Brown-Weiss 1989):

- securing mankind's existence,
- upholding society's productive potential,
- keeping options for action and development open.

These goals are more clearly concretized in the next step by sustainability rules, which apply to various societal areas, or to certain aspects in the relationship between society and the natural environment (Tab. 1). Such material "What"-Rules present minimum requirements on content for attaining the three general goals. Further, instrumental "How"-Rules were also formulated, which concern the method of fulfilling these minimum requirements (Tab. 2). Here, it is a question of which basic institutional, political, and economic conditions have to be given in order to be able to put sustainable development into practice, that is, to promote its realization.

The ecological, economic, social, and political dimensions of sustainability are treated as equal in this system of rules. Improvement of the economic and social living conditions should – on the global level – be brought into harmony with long-term protection of the natural basis of subsistence. The rules are, on the one hand, supposed to serve as guidelines for the further operationalization of sustainability (e. g., to determine suitable indicators for monitoring observance of the rules (Kopfmüller et al., 2001). On the other hand, they also have the function of normative criteria of supervision with the help of which conditions or developments can be judged with regard to sustainability. The requirement for making distinctions through the concept of sustainability, as expressed at the outset, is therefore fulfilled by this system of rules.

Conflicts of goals between rules can exist on various levels. First of all, it is not to be ruled out that – due to the concrete situation – simultaneous observance of (all of) the rules, is not possible. Undiminished population growth, for instance, could render it impossible to satisfy the basic needs of the world population without breaking the ecological rules of sustainability. Sustainability could then, in principle, no longer be ensured. Further, conflicting resource uses are also conceivable, which, for example, let the precept "to preserve landscapes of especially characteristic nature and beauty" come into conflict with the demand for securing an independent livelihood. Other conflict potentials can arise whenever it is a matter of translating the sustainability precepts inherent in the rules into concrete responsibilities of action for societal actors. In such conflicts, each rule can be valid only within the limits set by the others. There has to be an essence which may not be disregarded. For instance, the postulate of securing the subsistence level for all people, can, depending on the respective national context, be interpreted quite differently – in its essence, however, it merely stipulates that everyone must at least be able to survive.

The conflict potential included in the sustainability rules shows that even an integrative concept of sustainable development is not a harmonistic concept. Rather it leads to the situation that many well known societal conflicts can be seen as sustainability conflicts. The integrative nature of sustainability increases

the number of relevant conflicts because more aspects and issues are regarded as sustainability aspects and issues so that the number conflict-generating combinations also increase. This approach is "honest" in the way that it is able to uncover those – otherwise hidden and tacit – conflicts in defining, concretising and implementing sustainable development. In this way, conflicts in the sustainability debate are by no means to be avoided or seen as disturbing elements but rather are at the heart of any activities to make sustainability work. It becomes obvious that conflicts are inherent in every stipulation of sustainability strategies, and that rational conflict management is, therefore, of great importance.

The Leitbild of sustainable development remains a political and normative notion also in the scientific attempts of clarifying. This situation implies that it will not be possible to provide a kind of "algorithm" for assessing developments, measures or technologies with respect to sustainability. What can be done is, however, to clarify the framework for assessments, judgments and societal decision-making to a maximal extent in order to support transparent, well-informed and normatively-orientated societal processes of deliberation on sustainability.

4. Guiding Principles for Transforming the Energy System towards Sustainable Development

/this chapter is still completely "under construction". For German-speaking readers we insert a text which should give some ideas about what we concluded from the integrative concept as being most relevant to the field of energy/

4.1 Guiding Principles based on the integrative concept

Unter Berücksichtigung dieser Vorschläge sowie in dem Versuch einer Übertragung des integrativen Ansatzes der HGF werden nachfolgend einige allgemeine Handlungsleitlinien aufgeführt. Sie sollen als generelle Orientierung für die im Energiesektor handelnden Akteure bzw. für (politische) Handlungsstrategien dienen (*UN-ECOSOC* 2000 oder *UNDP/SEI/UNCSD* 1997):

Ressourcenschonung: Im Sinne der ressourcenbezogenen Nachhaltigkeitsregeln (siehe Anhang 1) sind kommenden Generationen die Nutzungsoptionen für die verschiedenen Energieressourcen offen zu halten. Neben den Energieressourcen selbst muss dies auch für nicht-energetische Ressourcen gelten, die im Zusammenhang mit der Förderung, Umwandlung und Nutzung von Energie verbraucht werden.

Umwelt-, Klima- und Gesundheitsverträglichkeit: Gemäß den Nachhaltigkeitsregeln zur Senken- und zur Gesundheitsproblematik (siehe Anhang 1) sind Überlastungen der Regenerations- und Anpassungsfähigkeiten der natürlichen Syteme sowie Gefahren für die menschliche Gesundheit zu vermeiden.

Soziale Gerechtigkeit: Für alle Menschen sind vergleichbare Chancen des Zugangs zu Energieressourcen bzw. -dienstleistungen zu gewährleisten.

Demokratie/Partizipation: Bei der Gestaltung von Energieversorgungssystemen ist insbesondere zu gewährleisten, daß allen Betroffenen die Teilhabe an den jeweiligen Entscheidungsprozessen möglich ist. Die Handlungs- und Gestaltungsspielräume von Akteuren bzw. von Gemeinwesen dürfen durch diese Systeme nicht eingeengt werden, sondern sind möglichst zu erweitern.

Dauerhafte Versorgungssicherheit: Die zur Befriedigung der nachhaltigkeits-kompatiblen Bedürfnisse erforderliche Energie muss dauerhaft und in ausreichender Menge zur Verfügung stehen. Hierzu sind z. B. räumliche und energieträger-bezogene Diversität sowie Sicherheitsspielräume hinsichtlich der Quellen anzustreben, um auf unvorhersehbare Krisen reagieren zu können und um generell Handlungsspielräume für die Zukunft zu erhalten bzw. zu vergrößern. Ebenso sind leistungsfähige Versorgungsstrukturen zu schaffen bzw. zu erhalten.

Risikoarmut und Fehlertoleranz: Unvermeidbare Risiken bei der Energieerzeugung und -nutzung sind grundsätzlich zu minimieren sowie in ihrer räumlichen und zeitlichen Ausdehnung zu begrenzen. Hierbei sind auch fehlerhaftes Verhalten, unsachgemäße Handhabung oder der mutwillige Zerstörung zu berücksichtigen.

Umfassende Wirtschaftlichkeit: Das Energiesystem ist - in Relation zu anderen Kosten des Wirtschaftens und des Konsums – zu vertretbaren gesamtwirtschaftlichen Kosten zu gestalten. Das Kriterium der „Vertretbarkeit" bezieht sich dabei zum einen auf die reinen betriebswirtschaftlichen, im Zusammenhang mit der Energieerzeugung oder -nutzung entstehenden Kosten. Zum anderen schließt es auch die Inanspruchnahme anderer Produktionsfaktoren wie Arbeit und natürliche Ressourcen ein, also auch die externen ökologischen und sozialen Kosten, zumindest soweit diese ermittelt werden können.

Internationale Kooperation: Die Gestaltung der Energiesysteme auf der internationalen Ebene soll Destabilisierungstendenzen und etwa durch den Mangel an Ressourcen bedingte Konfliktpotentiale vermeiden und die friedliche Kooperation der Staaten fördern. Gleichzeitig sind bi- und multilaterale Kooperationen bei der Gestaltung dieser Systeme anzustreben (im Rahmen von Entwicklungszusammenarbeit oder Technologietransferaktivitäten).

Gemäß der konzeptionellen Logik des integrativen Ansatzes der HGF sind diese Leitlinien zum einen als Gesamtheit zu betrachten, d. h. jede Leitlinie gilt im Prinzip nur in den Grenzen aller anderen. Zum anderen sind sie - wie oben angesprochen - als **Mindestanforderungen** einer nachhaltigen Entwicklung zu sehen. Das bedeutet, dass in einem solchen Konzept Elemente wie Wachstum, Wohlstand, Luxus usw. zwar nicht grundsätzlich ausgeschlossen, jedoch insoweit als nachrangige bzw. abhängige Größen zu betrachten sind, als sie nur in dem Maße zulässig sind, wie sie die Einhaltung der Mindestbedingungen für Nachhaltigkeit insgesamt nicht gefährden.

4.2 Strategische Optionen

Weitgehende Einigkeit besteht darin, dass die mittelfristige Realisierung möglicher Effizienzsteigerungen von bis zu 80 % und die Erreichung eines Anteils regenerativer Energieträger von 50 % nur über das Zusammenwirken verschiedener Maßnahmen möglich sein werden. Technologische Innovationen und die Umsetzung bereits verfügbarer sinnvoller technologischer Optionen in den verschiedenen Bereichen werden dabei eine wesentliche Rolle spielen. Beispielhaft zu nennen sind hier etwa verbesserte Energiewandlungstechnologien in Kraftwerken und dezentralen Anlagen, Kraft-Wärme-Kopplungssysteme, energie- und Material sparende Produktionsprozesse, Brennstoffzellen in stationärem und mobilem Einsatz, verbrauchsärmere Fahrzeugantriebe, Wärmedämmungstechnologien, Niedrig-, Null- oder Passivenergiehäuser, verbesserte Haushaltsgeräte, Speichertechnologien für den Einsatz erneuerbarer Energien oder Weiterentwicklungen im Bereich Photovoltaik oder Solarthermie (vgl. BMWA 2005, RNE 2004, Ha-

ke/Eich 2005). Darüber hinaus gelangen auch Themen wie die Kernfusion (Milch 2003), die Kernenergie angesichts der Hoffnung auf so genannte inhärent sichere Reaktoren (BMU 2004a) oder auch die Abtrennung von CO_2-Emissonen direkt bei ihrer Entstehung und ihre „Lagerung" etwa in der Tiefsee (Kemfert/Schumacher 2005) in die Debatte.

Vieles spricht jedoch dafür, dass technische Effizienz- und Substitutionsansätze alleine zumindest auf längere Sicht für eine global nachhaltige Entwicklung im Energiebereich nicht ausreichen werden. Hinzukommen müssen auch an der wesentlichen Ursache des globalen Energieverbrauchs – der Höhe und Beschaffenheit des Lebensstandards in den Industriestaaten – ansetzende Strategien. Beispielsweise mit dem Ziel, das Mobilitätsverhalten dahingehend zu ändern, dass motorisierte Verkehrsmittel nicht nur effizienter (s.o.), sondern auch in geringerem Umfang genutzt werden.

Für all dies bedarf es auch institutioneller, organisatorischer und sozioökonomischer Innovationen, angemessener politischer Rahmenbedingungen in Form von zum Teil tief greifenden ordnungs-, preis- und planungspolitischen Instrumentarien sowie vermehrter zielgerichteter Forschungsanstrengungen.

Effizienz

Konsistenz

Suffizienz

Randbedingungen:

lange Zeitskalen für Innovation im Energiebereich (Jahrzehnte)

Liberalisierung/Globalisierung, neue Akteure, NGO, abnehmende Macht der Nationalstaaten

5. Sustainability assessments

5.1 The necessity of prospective assessments

Shaping adequate measures for sustainable development requires anticipatory sustainability assessments in order to allow distinctions between more or less "sustainable" paths (Fleischer/Grunwald 2002). To be able to shape measures and strategies in favour of sustainable development, the assessments of the sustainability of the technologies under consideration have to be performed in the course of their development and *in advance* of the relevant decision-making. *Prospective knowledge* on the sustainability effects of the production, use, and disposal of these technologies has to be made available. 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.

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; has still to be adapted to the energy challenge):

- *Orientation Knowledge*: The scientific explication of sustainability-relevant phenomena is only one element among others in the knowledge required for sustainability. The appraisal of societal cir-

cumstances 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 2003).

- *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 (Wright 1971). Philosophy of science concerns itself above all with the fundamental conceptual and methodical principles of scientific explanation (Schurz 1988).
- *Knowledge for Action*: Foresighted knowledge of sustainably-efficient 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. 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.

5.2 Methodical challenges

In performing prospective assessments of the consequences and impacts of transformation measures concerning the energy system (including the introduction of new technologies, regulation, promotion, subsidies, information campaigns etc.) and especially in providing the required knowledge (see above) some typical and serious methodical challenges have to be dealt with (Grunwald 2007):

The Inseparability Issue: In order to assess proposed measures in terms of sustainability, it is essential that the sustainability effects are co-determined by the elements of technology and social or institutional elements. Technology as such is neither sustainable nor unsustainable. The contributions of technology to sustainability are only partially determined by technical parameters; the ways in which technologies are used and embedded into society exert a strong influence (Fleischer/Grunwald 2002; Sorensen/Williams 2002). Sustainability assessments have to take into consideration technology as well as societal processes, structures, values, customs, etc. that might be affected by the manner in which the technology is embedded in society. This means that the effects of technology on sustainable development also include a – possibly extended – set of societal aspects. The inseparability of technology from society clearly leads to uncertainties in the knowledge created because of the systemic nature of societal interaction with new technologies, for example, as a result of feedback loops and the emerging effects of self-organisation (Voss et al., 2006).

The Life Cycle Issue and the Prediction Problem: This problem is concerning especially technology assessment. Shaping technologies for sustainable development requires *anticipatory* assessments of sustainability to make it possible to distinguish between more or less "sustainable" technologies (Fleischer/Grunwald, 2002; Sorensen/Williams, 2002). Such anticipatory assessments are concerned with 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 manufacturing areas where components of a system are produced, extends to the – intended and possibly unintended – use of the technology in society, the impacts and consequences of the use for both the natural environment and society, and finally must take into account the disposal of these products. Sustainability assessments of technology must consider any effects on sustainability over time, especially the net effect on sustainability during the complete life cycle. In prospective assessments, however, the life cycle lies in the future. This means that "prospective life cycle analyses" are needed. They have to deal with the problem of conceptualising and assessing future developments: consumer and production patterns, future developments of lifestyles and markets, political and economic boundary conditions for the later usage of new technologies are just some examples of aspects of the future which should be known *in advance* in order to provide decision-guiding life-cycle analyses as part of sustainability assessments (example to be elaborated: the strongly increasing of biomass for energetic purposes).

The Completeness Issue and the Incompleteness Problem: The normative dimension of sustainability shows many different and heterogeneous aspects, ranging from dealing with natural resources to organising society around postulates of equity and justice (Kopfmüller/Grunwald 2006). Many fields have to be observed, and a large number of indicators have been proposed in order to fully picture the empirical societal situation of sustainability (Kopfmüller et al., 2001; Opschoor et al., 1991). However, there can be no guarantee that this specific "full picture" will really be derived from the assessment. Relevant sustainability aspects might be simply overseen or excluded from further consideration after being erroneously deemed of low relevance in that field. It is impossible for philosophical, economic, and pragmatic reasons to gain a complete picture in investigating sustainability aspects of a new technology. Decisions have to be made on the relevance or irrelevance of specific dimensions, and the limitations of the systems considered. Such decisions, however, are risky in themselves, and these risks have to be dealt with pro-actively.

The Integration Issue and the Incommensurability Problem: The same initial conditions – many different and heterogeneous aspects of sustainability, ranging from managing natural resources to organising society in

terms of postulates of equity and justice and thereby observing many completely different indicators (cf. Grunwald/Kopfmüller, 2006) – also lead to a different methodological issue: the heterogeneity of the various dimensions and indicators of a technology's sustainability means no common measure of sustainability can be applied to them as a whole. In terms of method, it not satisfactory to measure emissions of greenhouse gases, numbers of people affected by long-term unemployment, information on cooperation with developing countries, or the existence of civil society organisations and engagement according to the same unique scale. 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 without incurring severe methodological problems. As the sustainability imperative is integrative by nature, any attempt to integrate data or assess results from heterogeneous aspects of "overall" sustainability demonstrates normative dimensions which strongly limit the use of common decision-analysis tools. Rather, discursive tools must be used, and political decisions made (example still to be elaborated: the attempt of the ILK to assess the sustainability of different energy technologies by applying MCDA).

6. Framing the field – some conclusions

Strategic knowledge for sustainable development consists of combinations of orientation-, explanatory, and action-guiding knowledge (see above). The generation of this strategic knowledge is a new type of challenge for the science system. The classical structure and development of the sciences in the direction of increasing specialization alone is, for these challenges, not purposive. It has to be complemented by a new "culture" of integrative research, which crosses disciplinary borders; which treats questions of values transparently, but without contact anxieties; which is internationally organized; and which extends from basic research to concrete applications. This situation implies a considerable increase in the demands on reflexivity in the sciences. Normative premises, cognitive presuppositions, the limits of the system observed, relevance judgements made, and knowledge of the epistemological limitations of knowledge of the first order have to be revealed transparently, as does knowledge of inherent uncertainties. Society and policymakers not only have to be provided with action-guiding knowledge, but also with instruction about how this knowledge is to be interpreted and where its limits 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 implementing 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.

The transformation of the energy system towards sustainable development concerns a lot of different issues which are relevant to the social sciences and especially the STS community. We have to make further progress in

- analysing further the normativity involved in sustainability (goals, guiding principles etc.) especially concerning the role of normative presuppositions in conflicts and conflict-solving
- dealing with socio-technological systems relating technological advance in energy systems with behaviour of consumers
- addressing the governance of energy systems (industry, NGOs, role of consumers, role of regulation, steps towards global governance etc.)
- investigating energy futures (expectations, fears and hopes, scenarios, roadmaps etc.) with respect to their normative and cognitive content as well as with regard to their strategic role in decision-making and public deliberation in order to make them more transparent and open for deliberation
- establishing comprehensive innovation strategies for transformation steps – from talking about "potentials" of new energy technologies to talking about realising the potentials

The imperative of sustainability has often been criticized to the effect that it generates a false sense of harmony. In this paper, the thesis is proposed that, in contrary, conflicts arise on all of the levels of making the concept of sustainable development work – not only when concrete political measures are put to debate. Such conflicts are, regularly, rooted in plural societal values, different images of humankind and nature and different ideas about future society, and are part of the expression of different interests. The paper suggests that these conflicts could and should be used to define the more concrete societal understanding of sustainability in the field of energy and ways to approach it. It is stated and argued for that new cultures of conflict-solving should be established across existing cultures and traditions. Conflict management can itself be understood as a process oriented on the imperative of sustainability. The instrumental rules of sustainability (Tab. 2) show that demands for self-organization, reflectiveness, and the balance of power have consequences for the manner in which the corresponding conflicts should be settled (these rules are obviously far removed from any sort of naturalism). Sustainability's demands for equal opportunity and participation are in this respect also not inconsequential (Grunwald 2005).

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Table 1: Substantial rules of sustainable development (Kopfmüller et al. 2001)

General sustainability objective: Securing human existence
Protection of human health: Hazards and unacceptable risks to human health due to anthropogenic environmental burdening must be avoided.
Ensuring basic needs: Every member of society must be assured a minimum of basic supplies (housing, food, clothing, health care) and protection against fundamental risks to life (sickness, disability).
Securing an autonomous existence: All members of society must be given the possibility of securing their existence by voluntarily undertaken activities (including education of children and care of the elderly).
Fair sharing in the use of natural resources: Utilizing natural and environmental resources must be distributed according to the principles of justice and a fair participation of all persons affected.
Balancing extreme inequalities in income and wealth: Extreme inequalities in the distribution of income and wealth must be reduced.
General sustainability objective: Maintaining society's productive potential
Sustainable use of renewable resources: The rate of utilizing renewable resources is not to exceed the regeneration rate or endanger the ecosystems' capability to perform and function.
Sustainable use of non-renewable resources: The range of proved non-renewable resources must be maintained.
Sustainable use of the environment as a sink for waste and emissions: The release of substances is not to exceed the absorption capacity of the environmental media and ecosystems.
Avoiding unacceptable technical risks: Technical risks with potentially catastrophic impacts on humanity and the environment must be avoided.
Sustainable development of man-made, human and knowledge capital: Man-made, human and knowledge capital must be developed in order to maintain or improve the economy's performance.
General sustainability objective: Preserving development and action options
Equal opportunities: All members of society must have equal chances to access education, occupation, information and public functions as well as social, political and economic positions.
Participation in societal decision-making processes: Every member of society should be given the opportunity to participate in relevant decision-making processes.
Conservation of cultural heritage and diversity: Human cultural heritage and cultural diversity must be preserved.

Conservation of the cultural function of nature: Cultivated and natural landscapes or areas of special uniqueness and beauty have to be preserved.

Conservation of social resources: To ensure societal cohesion, the sense of legal rights and justice, tolerance, solidarity and perception of common welfare as well as the possibility of non-violent conflict settlement must be enhanced.

Table 2: Instrumental rules of sustainable development (Kopfmüller et al. 2001)

Short title	Full description
Internalization of external social and environmental costs	Prices have to reflect the external environmental and social costs arising through the economic process.
Adequate discounting	Neither future nor present generations should be discriminated through discounting.
Debt	In order to avoid restricting the state's future freedom of action. its current consumption expenditures have to be financed, as a matter of principle, by current income.
Fair international economic relations	International economic relations have to be so organized that fair participation in the economic process is possible for economic actors of all nations.
Encouragement of international cooperation	The various actors (government, private enterprises, non-governmental organizations) have to work together in the spirit of global partnership with the aim of establishing the prerequisites for the intiation and realization of sustainable development.
Society's ability to respond	Society's ability to react to problems in the natural and human sphere has to be improved by means of the appropriate institutional innovations.
Society's reflexivity	Institutional arrangements have to be developed, which make a reflection of options of societal action possible, which extend beyond the limits of particular problem areas and individual aspects of problems.
Self-Management	Society's ability to lead itself in the direction of futurable development has to be improved.
Self-Organization	The potentials of societal actors for self-organization have to be increased.
Balance of Power	Processes of opinion formation, negotiation, and decision-making have to be organized in a manner which distributes fairly the opportunities of the various actors to express their opinions and to take influence, and makes the procedures employed to this purpose transparent.

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