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Stuttgarter Beiträge zur Risiko- und Nachhaltigkeitsforschung

Energy technology roadmap and stakeholders' perspective: Establishment of social criteria for energy systems

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Nr. 6 / Juli 2007

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Report

NEEDS
New Energy Externalities Developments for Sustainability
INTEGRATED PROJECT

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ISSN 1614-3035
ISBN 978-3-938245-06-4

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Acknowledgement

We especially thank Stefan Hirschberg and Roberto Dones from the Paul Scherrer Institute for their encouragement and patience in bringing this report to fruition. They both put a lot of effort into this report and the set of social indicators by giving us advice and specific proposals on items, had meetings with us for discussing different matters and also reviewed and commented various draft versions. Therefore, we would like to give sincere thanks. We also want to acknowledge the contributions provided by our project partners Hélène Connor, Christophe Rynikiewicz from HELIO International and Ilona Graenitz from GLOBE Europe. They helped us by developing, reviewing and commenting the set of social indicators and supported our work in this way. Special thanks are also due to the colleagues from the University of Stuttgart, in particular Kathrin Ulmer, Wolfgang Weimer-Jehle, Julia Ortleb, Sabine Mertz, Jörg Hilpert and all the others who supported our work.

Abstract

This report will inform about the development and selection of social indicators for the measurement of social effects of energy systems. As in the NEEDS project the aim of Workpackage 2 is to define social indicators for the assessment of social effects of energy systems, we applied a multi-step-approach. In a first step, we looked for existing indicators available in publications from the last twenty years. The keywords "social indicator", "sustainability", environmental indicator" and "energy indicator" have been used to organise this research process. As a result of this research process 1320 indicators could be found. In a second step, these indicators have been proved according to the following meta-criteria:

1. The clarity of the indicators.
2. Whether the indicators are simple and logical.
3. Whether the indicators can be applied throughout Europe.
4. Whether they combine social and energy system-related aspects.

Only 148 of the 1320 criteria passed this step of the research process. These indicators have been proved according to three main questions, which should make sure that the indicators are suitable with the requirements of the NEEDS project:

1. Whether they can be applied to future technologies.
2. Whether their focus is on the level of countries and not only on the regional level.
3. And whether the indicators allow differentiating between energy technologies.

Only 26 of the 148 indicators passed this filter process and are able to measure the social dimension of present and future energy systems. These indicators have been attributed to concepts derived from the theoretical concept of social compatibility (Häfele/Münch/Renn 1985). With reference to the theoretical concept of social compatibility we allocated the indicators to four main criteria, these criteria are:

1. Continuity of Energy Service over Time
2. Political Stability and Legitimacy
3. Social Components of Risk
4. Quality of Life.

For every criterion suitable indicators have been defined and added. Those mentioned criteria and indicators build the basis of our social indicator-set. The indicators will be measured with reference to the four main life cycle phases of energy systems: energy extraction and processing, transport, power plant (conversion to electricity) and waste management (considering the entire back-end).

An updated version of indicators will be the outcome of a Stakeholder-Delphi. The stakeholders are invited to the Delphi to give a crucial input for the final version of the social indicators. The results of the Delphi and the final set of the social indicators will be added to the present report and complete it.

1 The Objective of the NEEDS project

The objective of the NEEDS project is to evaluate the full costs and benefits of energy systems and energy policies, both for individual countries and for Europe. While the debate on the internalisation of external costs of energy systems is usually focused on environmental costs, the NEEDS project also addresses the social components. Within the NEEDS project, one of the genuine tasks of Research Stream 2b is the definition of indicators[1] for the assessment of social effects of energy systems. Doing that, Research Stream 2b intends to extend the evaluation basis for the internalisation of external costs of

[1] The term "indicator" can be defined in various ways. For example:

- An indicator is a variable that describes the state of a system. (Walz et al. 2000)
- Indicators arise from values (we measure what we care about), and they create values (we care about what we measure). (Meadows 1998)
- Indicators are presentations of measurements. They are bits of information that summarize the characteristics of systems or highlight what is happening in a system. Indicators simplify complex phenomena, and make it possible to gauge the general status of a system. (…) An indicator quantifies and simplifies phenomena and helps us understand complex realities. (IISD 2000a, http://iisd1.iisd.ca/measure/faqs.htm)
- (An indicator is) "A parameter, or a value derived from parameters, which points to, provides information about, describes the state of a phenomenon/environment/area, with a significance extending beyond that directly associated with a parameter value" (OECD 1994: 9; OECD 1998: 107).

In this report we will use the definition of indicators, which was developed by the OECD. By parameters we mean "a property that is measured or observed" (OECD 1994: 9; OECD 1998: 107).

energy systems. In order to do this, the existing scientific literature has been reviewed to collect existing indicators for the evaluation of the social dimension of energy systems. Where the review of the literature did not lead to applicable indicators, new indicators had to be developed. This report gives an overview on the selected indicators. An updated version of indicators will be the outcome of an Expert-Delphi. This will form the basis for the final selection of social indicators that will be integrated into the corresponding sets of environmental and economic indicators established in Research Stream 2b. This integration will require some readjustment to avoid redundancy and to identify potential gaps or needs for revisions.

2 Internalisation of externalities

According to the economic theory, economic actors act in a rational way, when they maximise the expected output of their investments. But, as the debate on external costs has shown, this is only true when the market prices of a good or a service reflect the full costs. If there are components of the costs, which are not reflected by the price, the allocation of resources according to distorted prices leads to sub-optimal solutions.

One of the fields where the appropriateness of prices and their relevance as indicators of the real costs are discussed is the field of energy supply. Among others, environmental NGOs point out, that the environmental effects as well as the social impacts of energy systems are not sufficiently reflected by the prices. Full costs can be defined as the sum of market prices and external costs (benefits), i.e. those costs (benefits) that are not included in the market prices but represent (dis)utilities associated with the production, consumption or disposal of the good. While it is easy to assess market prices, the assessment of external costs is a difficult challenge.

The problem is, how to define, assess and measure external costs[2]. The definition and measurement of external costs is far from being trivial and it is more difficult in the sphere of social impact than it is in the sphere of environmental impacts. Theoretical concepts trying to define social functions, which are necessary for the existence of a society, have been contradictory (compare e.g.: Parsons 1952, Münch 2004, Luhmann 2002).

But it would be misleading to conclude from the problems in finding a consensus on essential societal functions that the social sphere should be neglected or ignored. The history of energy politics, in

[2] See for further discussion on external costs: Connor, H. 1999.

particular with respect of nuclear policies, has demonstrated how important the social dimension is for decision-making processes. The challenge is how to define a rationale for the systematic delineation of social indicators, which allows integrating the social dimension of energy systems into the decision-making process. In order to develop such a rationale it is important to distinguish three sociological approaches to address this question:

1. Social indicators research
2. Research on the social dimension of sustainability
3. Studies on the social accountability of energy systems.

2.1 Approaches to conceptualise and measure the social effects of energy systems: Social Indicators Research

In the 1960s, growth oriented economic indicators such as the GNP dominated the discussion on the welfare of nations. This dominance of economic indicators has been criticised by social scientists who claimed that these measures are inappropriate to represent the welfare of societies. In consequence, social indicators research was developed to provide the information of an informed social policy and to measure social change in the tradition of William F. Ogburn (1950). The starting point for this development was a NASA project aimed at studying the social impact of space research. Scientists involved in this project did not only claim a lack of appropriate data, but also a lack of scientific methods to study the problem.

"The felt need was for more adequate monitoring and reporting of social conditions and processes – implying a need to develop improved measures of these phenomena, together with expanded data collection capabilities. Thus the dual goals of the social indicators movement were apparent from the start: to establish an improved social reporting capability as soon as possible and to encourage long-term research and development in the general area of social measurement and model-building" (Johnston 1990: 433, cited acc. to Habich, Noll 1993: 5). According to a definition from Wolfgang Zapf (1977: 5) social indicators are all statistical information, which are relevant considering the quality of life, modernisation and an active societal policy.

2.2 Approaches of the Social Indicators Research

Since its development in the 1960s, social indicators research has mainly concentrated on the measurement of quality of life and the quality of living conditions. One example for such empirical studies is the German Wohlfahrtssurvey (German-Socio-Economic-Panel), a large panel study based on households that allows analyses of the development of individual living conditions. Another example is the world database on happiness collected by the Dutch psychologist Ruut Veenhoven (http://www2.eur.nl/fsw/research/happiness). The major task of social indicators research is the production of social reports, which inform society about the conditions of life in a given society.

There are different understandings of what quality of life means. Social indicators research distinguishes between objective and subjective indicators. While the American quality-of-life approach concentrates on subjective indicators and measures the satisfaction of people with their lives and their conditions of life, the Scandinavian resource-approach focuses on objective indicators for the measurement of quality of life. The German approach is a combination of both approaches (for the discussion of theoretical concepts for the measurement of quality of life see Zapf 1984).

Social indicators research has produced different sets of social indicators[3]. The World Data Base on happiness is one of the most widely used approaches. The task group on social indicators of the ZUMA in Germany has collected time series for about 400 different indicators[4]. In general, social indicators research has experienced a wide international application and popularity, at least for the decades between 1960s and 1980s[5]. National reports about the quality of life in various European countries differ slightly in the dimensions they address[6], but there is an emerging consensus among social scientists that social indicators should reflect topics such as population and demography, labour market, income, housing, health and social security. Most national and international indicator systems do include those aspects.

Despite its success in the field of social reporting, social indicators research faces one central problem: It focuses on individual quality of life and the individual's perception of his or her quality of life. It reflects more the aims of traditional social policy than attempts to internalise external costs. Authors like Esping-Andersen (2000) have criticised social indicators research as being only descriptive and collecting data without an underlying theoretical conception, which ideally should guide the selection of criteria and indicators.

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[3] See for an overview Noll 2002.

[4] See Habich/Noll 1993.

[5] Noll 2002.

[6] Habich/Noll 1993.

3 The Concept of Sustainability

Another more recent approach to deal with the issue of social impacts of energy systems is linked to sustainability, which addresses the matter in a more sophisticated way. After the publication of the Brundtlandt Commission report (1987), the term "sustainability" has become one of the most popular goals of political and scientific actors. The Brundtlandt Commission defined sustainable development as a process meeting "the needs of the present without compromising the ability of further generations to meet their own needs". The concept of sustainability, as it was formulated by the Brundtlandt Commission, was developed in order to address two interrelated problems: the global ecological crisis and the increasing global discrepancies between the North and the South. It assigned equal importance to two time reference levels: the present and the future integrating the intragenerational and the intergenerational dimensions. Combining both objectives, sustainability implies that the needs of the people living in the present should be met, but in a way which does not compromise the ability of further generations to satisfy their needs (see Renn 1994; Renn/Kastenholz 1996: 92; Knaus/Renn 1998: 61).

The popularity of the term "sustainability" increased after the Rio Declaration of 1992. According to this declaration, sustainability addresses a healthy and productive life in harmony with nature (principle 1) as well as the health and integrity of the earth's ecosystem (principle 6). In this understanding, sustainable development focuses on ecological principles, but other goals are added, for example, eradicating poverty (principle 5), the participation of all concerned citizens in societal issues (principle 10) and the inclusion of women in decision-making processes (principle 20)[7].

But despite the popularity of the "sustainability concept", there is no general consensus about the definition of sustainability. Reflecting very heterogeneous goals, sustainability seems to be far away from producing a common understanding among different science and policy camps (see Tremmel 2003). According to Kreibich (1996: 40), there are about 70 divergent definitions of sustainable development in the international discussion[8]. The lack of analytic precision may be due to the fact that sustainability did not start as a scientific concept but as a political and ethical goal and its conceptual foundations remain at the very general level addressing values such as justice and stability.

Systematically, most authors distinguish the following three dimensions of sustainability (see Weber-Blaschke, Mosandl, Faulstich 2004: 8):

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[7] http://www.unep.org/Documents.Multilingual/Default.asp?ArticleID=1163&DocumentID=78&l=en

[8] Also Jüdes (1997) and Pezzey (1992) point this out.

Some Examples of definitions of sustainability:

- "Sustainable development means living on the earth's income rather then eroding its capital." (DoE 1996: 1)
- "Sustainable development means to use less nature, to include more people." (Sachs 1999: 76)
- "Sustainable development requires integration of economic, social and environmental concerns: Ensuring economic efficiency while respecting social equity and safeguarding ecological integrity." (OECD 2000: 150)
- "Sustainable development is not about compromise, but about integrating economic, environmental and social factors for long term benefit." (J.M. Smith Shell Chemicals 1999: Taking a measure of sustainability. In Morse 1999: 19).

1. Ecology
2. Economy
3. Society.

There are different views about the relative importance of these dimensions: some authors place priority on the ecological dimension, others define each of the three dimensions as equally important, and for others (e.g. Brand 1997) the social dimension should take priority. The latter preference seems to be surprising at first glance, but according to Brand (1997: 13), the concept of sustainability transforms the problem of the protection of the environment into a problem of the appropriate use of natural and social resources. He addresses sustainability as a new developmental path leading to self-containment when exploiting natural resources in respect of a) future generations, b) global opportunities for development and c) the inter-linkage of ecological, economic, and social aspects of development. But even in this understanding, the dominance of the social dimension in this approach is only linked to a procedural agenda, because also for Brand the central goal of sustainability is the societal organisation of ecological sustainability.

Many authors, who follow an anthropocentric understanding of sustainability, claim that the protection of the environment is not a goal of its own, but is an instrument for giving future generations the opportunity to satisfy their needs (weak sustainability). Other authors pursue a physiocentric understanding of nature and have developed a set of inviolate values linked to environmental quality that are independent of human benefits (strong sustainability).

Given the heterogeneous understanding of sustainability, it is not surprising that there is no consensus how to define, let alone conceptualise, the social dimension of sustainability. While some authors link social sustainability to the contribution of societies to reach the ecological goals of sustainability, other authors associate social sustainability with social justice and equality with respect to living conditions. These two understandings of sustainability are problematic, because an ecological framing of social sustainability ignores other crucial factors that influence the conditions for meeting the needs of the present and future generations. But also a welfare-related understanding of sustainability raises problems: Social justice or social equality is only weakly correlated with the intergenerational dimension of sustainability. If one follows the understanding that social sustainability is directed towards intragenerational justice, social sustainability addresses more the level of consumption of goods than their production over time. If it is more linked to intergenerational justice, the continuity and availability of ecological, economic and social resources are at the core of the analysis.

A concept that addresses intergenerational sustainability has been developed by the World Bank (World Bank 1997). It differentiates between four types of capital: natural capital, produced/man-made capital, human capital and social capital. The goal of sustainability is to pass on to the next generation at least as much natural, economic, human and social capital as is at the disposal of the current generation.

Following an understanding of sustainability, which gives the social dimension the same analytic importance as the ecologic dimension, the problem of social sustainability addresses the societal organisation of processes, which lead to a path of overall sustainable development. For that reason, social institutions and institutionalised decision-making processes are as important for human beings as an unspoiled eco-system and the distribution of goods. Societies must be able to cope with problems over time (see Grunwald 2004). In modernization theory, the ability of systems to survive processes of change is described as "ultrastability" (Cadwallader 1959). Ultrastability means, that a complex social organisation persists even when the environment of the organisation is changing. Cadwallader appoints problems like information processing and the feedback of information as central topics for ultrastability.

Reflecting the dual ambitions of social sustainability, more than one goal has to be addressed. According to Grunwald (2004), three general goals have to be fulfilled: securing mankind's existence, upholding society's productive potential and keeping open options for developments and action. To reach these goals, Grunwald (2004: 115) has developed a set of rules (see table 1).

Table 1: Goals of sustainability

Goals	**Securing Mankind's Existence**	**Upholding Society's Productive Potential**	**Keeping Open Options for Development and Action**
Rules	*Protection of Human Health*	Sustainable Use of Renewable Resources	*Equal Access to Education, Information and Occupation*
	Securing the Satisfaction of Basic Needs	Sustainable Use of Non-Renewable Resources	*Participation in Societal Decision-Making Processes*
	Autonomous Self-Support	Sustainable Use of the Environment as a Sink	*Conservation of the Cultural Heritage and of Cultural Diversity*
	Just Distribution of Chances for Using Natural Resources	*Avoidance of Unacceptable Technical Risks*	*Conservation of Nature's Cultural Functions*
	Compensation of Extreme Differences in Income and Wealth	*Sustainable Development of Real, Human and Knowledge Capital*	*Conservation of Social "Resources"*

Source: Grunwald 2004: 115.

4 The need of participative decision-making processes for developing social indicators

As stated earlier, the objective of the NEEDS project is to evaluate the full costs and benefits of energy systems and energy policies, both for individual countries and for Europe. The specific objective of Research Stream 2b is the integrated evaluation of sustainability. To achieve this objective, indicators for the economic, the ecological and the social dimension of external costs of energy systems need to be developed. While ecological and economic indicators relate to dimensions most of which can be measured in quantitative terms, the measurement of social aspects creates more difficulty, on the conceptual and the empirical level.

Social indicators cannot be derived from an overarching functional societal theory because a consensually accepted theory about basic societal functions does not exist in the social sciences. Hence, most social theories restrict their focus on the description and interpretation of social actions at the micro- or meso-level looking into organisations, institutional settings, subjective orientation and instrumental functions etc. Two major types of theories have emerged in sociology to explain how values are selected and mentioned.

The first type of theory is the consensus theory. Consensus theories assess that society is maintained by shared opinions about norms and values, which are expressed in what Durkheim called a "collective conscience" (Etzioni 1993). Consensus theories are based on the assumption that social order is a product of negotiation and agreement and structural changes emerge through evolution. Furthermore, conflicts emerge among people or groups who deviate from social norms or societal rules and values. As a counterpart to consensus theories, conflict theories, the second type, try to explain the emergence and stability of commonly shared values and behavioural conformity. Theorists suppose that ruling groups impose their values upon others and that there cannot be an ultimate collective agreement referring to values (Coser 1956, 1967, Blalock 1989). Therefore social order is maintained only through patterns of dominance and power. Changes might only occur in consequence of sudden perturbations such as revolutions. Consensus has to be reached in a coercive way, because it convinces people to abandon their individual interests in exchange for a (real or alleged) amelioration of the majority's situation.

Both types of theories have been criticised. The consensus theories have been criticised for justifying dictatorships and totalitarian regimes (Bachrach 1967). Conflict theories have been criticised for ignoring the importance of aspects for social reproduction: individual aspects, society and the culture (Bernard 1983).

As it was pointed out, both types of theories are contested among peers and are not able to explain structures and important societal values in a generally accepted way. Furthermore, both types of theories are in their results limited to the macro-level of society. For example, social consensus theories, like structural functionalism (Parsons 1952) and social theories of conflict like the conflict theory of Marx (Marx 1971, Evans 1972) study the society as a whole. This is in contrast to micro-level social theories like the theory of social interaction by Weber or Mead, which places individual actions and motives in the centre of sociological explanations (Weber 1962; Mead 1934). Sociology is characterised by competing schools of thoughts and theories and many theories coexist about similar or identical phenomena. There is no common agreement on which theory can claim with universal validity to explain the behaviour of all social groups and individuals. The lack of theoretical agreement is accompanied by a lack of empirical strategies to identify basic functional requirements through observation and experimentation. Since most social interactions are highly interdependent and causal structures are not obvious when reporting human behaviour, any empirical analysis is forced to have a conceptual model about causes, intervening variables and effects in place before the empirical analysis can start. In addition, human behaviour is driven by mental processes that are not directly observable but rely on interactions between the researcher and the subject. Subjects, of course, have the possibility to hide their motives and behavioural options, to re-interpret their own motivations, or simply to lie to the researcher. Hence, two of the main problems in the social sciences are, firstly, the reliance on conceptual models for guiding empirical research (that cannot be justified by purely objective criteria) and, secondly, the empirical filter of research subjects when reporting their motives and pre-behavioural thoughts.

One possibility to treat both problems is the use of participative or recursive analysis. The researcher uses the research subjects for framing the main conceptual model and to revalidate the empirical results by comparing them with the interpretations of the subjects. The advantage of this method is that the subjects are in the driver seat and shape the research process. They have to agree on a common empirical research design and are empowered to assist in the interpretation of the results. The disadvantage is that these subjects can distort the results by having an interest in controlling the research design and the interpretation. Participatory analysis works best when subjects with many divergent interests and values are part of the analytical process. In this case they need to find a common understanding of the problem and the intention beyond each individual interest. Thus, they get closer to an intersubjective interpretation of reality.

In our project, this major condition is given since our task is to identify and select indicators for the social dimension of sustainability by including different value and interest communities. Rather than deducing indicators from theories, we build them upon consensual processes within participative procedures involving multiple stakeholders and multiple values and attitudes.

4.1 Participative decision-making processes

In addition to the knowledge generation aspect of participatory methods in the social sciences, there are normative reasons for choosing this alley of social research. Politicians and experts value the instrumental and legitimising function of feeding the values and preferences of people, who might be affected by the decisions they make, into the formal decision-making process. Traditional decision-making strategies, that do not consider citizen's values, are susceptible to two major criticisms: "First, because they de-emphasize the consideration of affected interests in favour of 'objective' analyses, they suffer from a lack of popular acceptance. Second, because they rely almost exclusively on systematic observations and general theories, they slight the local and anecdotal knowledge of the people, who are most familiar with the problem, and risk producing outcomes that are incompetent, irrelevant, or simply unworkable" (Renn/Webler/Wiedemann 1995: 1). Citizen involvement in decision-making processes addresses these problems. For our understanding and further research we adopt the definition of public participation from Renn et al. (1995). Here, public participation is defined as: "forums for exchange that are organized for the purpose of facilitating communication between government, citizens, stakeholders and interest groups, and businesses regarding a specific decision or problem" (Renn/Webler/Wiedemann 1995: 2). This definition explicitly excludes activities like protests or expert workshops. The focus is put on the fair opportunity for citizens to take part in decision-making processes and to insert their values into decisions that might affect themselves.

There are several methods to let people participate in decision-making processes. Depending on purpose and intention, methods vary from formal hearings over mediation to consensus conference and citizen panels. These methods can use specific participatory techniques such as multi-attribute decision analysis, value tree analysis or meta-plan procedures. The following chapters will illustrate the main features of participative analysis by using the examples of 'value tree analyses' in the context of the 'citizen panel' method. The combination of value tree and citizen panels was the main characteristic of a study on the social compatibility of energy systems that was initiated by the German Bundestag and conducted by a research team at the Research Center Jülich (Häfele et al. 1985).

4.2 Procedural concept of the definition of social externalities: The Concept of Social Compatibility

Lacking a functional theory of society, it is not possible to deduct externalities. What is defined as social effects and how these are evaluated, cannot be assessed without referring to the values in societies. For instance, whether the construction of a power plant is evaluated as a symbol of progress or as a blot in the landscape depends on the judgement of those making the evaluation, and this judgement depends on their value system. In addition to attempts to develop a deductive list of criteria and indicators for the measurement of externalities, there are also approaches, which attempt to define indicator systems with the aid of participatory methods. One of the early attempts in the field of energy indicators is the Jülich Energy study (Häfele et al. 1985; Renn et al. 1985; Renn 1986). In contrast to the concept of sustainability, which addresses the problem of the future functionality of societies, the Jülich Energy study addresses the problem from the perspective of the main social actors.

The concept of 'social compatibility' is based on the assumption, that decisions, which are made in the economic, political or technological field, should take into account societal values and visions. The considering of societal values in decision-making processes is seen as a crucial factor for understanding public concerns in order to affect the citizens' acceptance of decisions. Taking into account societal values is a difficult task because in every society, there are different kinds of groups with different values. This aspect raises the question of how a consensus on values can be accomplished that is acceptable to all members of society. A second question touches upon the inclusion or integration of the participatory results into the formal decision-making process.

The concept of social compatibility tries to give an answer to this question. Following this concept, values provide guidance for judging social desirability (Häfele et al. 1985: 50ff.). In this understanding, values describe "desirable circumstances in a society" (Renn et al. 1985: 56) and give orientations for distinguishing desirable from non-desirable social actions. As a result, decisions that are made by politicians or experts are acceptable to society as long as they adhere to common values and desirable aspects. Therefore it is important to know the values of society and to reach a consensus on those values that affect collective actions. These common values need to be accepted by every social group and individual. The concept of 'social compatibility' considers societies' values in decision-making processes by combining the three steps of a 'value tree analysis', an 'impact analysis' and a 'citizen panel' (Renn 1986).

4.3 The Value Tree and the Impact Analysis

The identification of concerns and values is best accomplished by asking all relevant stakeholder groups (i.e., socially organized groups that are or perceive themselves as being affected by a decision) to reveal their values and criteria for judging different options. It is important that all relevant stakeholder groups are represented and that a variety of value clusters, including economic, political, social, cultural, and religious values, is integrated into the analysis. Although strategic reasoning and hidden agendas may influence the responses of stakeholder groups, the mere listing of concerns as expressed in values and subsequently, the deduction of criteria helps to expose inconsistencies and to avoid hidden agendas. To elicit such values and criteria the technique of a value tree analysis has proven to be appropriate (Keeney et al. 1984; 1987). A value tree identifies and organizes the values of an individual or group with respect to possible decision options (Keeney et al. 1984; Keeney et al. 1987). In the process of structuring a value tree, representatives of different stakeholder groups are asked to identify their criteria and objectives for evaluating different options. Values in this context are abstractions that help to organize and guide preferences.

A value tree structures the elicited values, criteria and corresponding attributes in a hierarchy with general values and concerns at the top and specific criteria and attributes at the bottom. Depending on the political context and the nature of the decision to be made, the values of the various stakeholder groups may vary considerably. By giving each group the right to assign a weight of zero to each criterion that they regard irrelevant, it is possible to construct a joint or combined value tree that accounts for all viewpoints and can be verified by all participants (Keeney et al. 1984). Table 2 illustrates the six consecutive steps of eliciting value trees.

Table 2: The six steps of eliciting value trees

STEP NO:	DESCRIPTION OF THE STEP
1	Personal interview(s) between the analyst(s) and several representatives of the respective stakeholder group
2	Structuring the values, criteria, and attributes into a hierarchical order by the analyst(s)
3	Feedback of the value tree given to the stakeholder group for comments or modifications
4	Iteration of step 2 and 3 until stakeholder group is satisfied with the final product
5	Combination of all group-specific value trees into a single "megatree"
6	Validation of the megatree by all participating groups (with the option of assigning zero weights to criteria that they dislike)

Source: own consideration on the basis of Keeney et al 1984.

Value trees have proven to be useful instruments for structuring the underlying dimensions of a debate and for linking general concerns of groups with concrete options they favour or disfavour (Keeney et al. 1987). In this respect value trees help to focus the attention on issues that seem to underlie conflicts about the selection of options and they help to develop a mediation program between conflicting groups. Value trees are, however, contingent on the basic assumption of decision analytic models, that generating criteria for evaluating options and assessing the performance of each option on the criteria can be analytically separated into two independent tasks (von Winterfeldt and Edwards 1986).

After arranging values and criteria in a joint value tree, indicators for the preferred values are derived that are supposed to cover all dimensions that correspond to the selected values. This step is called 'impact analysis' because it is focused on the impacts that might be associated with each of the values. It is also focused on the aspects, which need to be considered when measuring the values. Values and criteria constitute abstract notions and cannot be measured but only be transformed into indicators, i.e. operational rules for measuring the intention of each value. For example, if people associate risks with a nuclear power plant they need indicators to measure the various dimensions of risk. Candidates for indicators would be 'health effects', 'reduced life expectancy' or 'number of children with allergic reactions' etc. If researchers know the preferences and values of the various constituencies, factual information about the consequences of different decision alternatives and the hierarchical model of values and criteria can be used to find the most preferred alternative for the solution of the underlying problem. Therefore, it is the aim of this analysis to collect all criteria and values that are mentioned by social groups and individuals. By using an iterative process, the values are structured according to the subjective importance that different groups attribute to them.

After having determined the indicators and having measured the effects of each decision option, one still faces the problem of relative weights that can be assigned to each indicator. It is very unlikely that one decision option outperforms all other options on each criterion. Who should be entitled to assign the relative weights to each indicator in order to determine the most suitable decision option? The Jülich compatibility study used citizen panels for this task. This method is treated in detail in the following section.

4.4 The Citizen Panel

A Citizen Panel is a 'deliberative' form of participation. Deliberative participation differs from normal public participation because it is not aimed to predetermined answers on predefined questions framed by policy makers. Instead, it is the aim of the citizen panel to let citizens express their experiences and priorities in a certain issue, and to frame their own suggestions and recommendations for policy makers to consider.

The model of citizen panels is based on a concept developed by P.C. Dienel in the 1970s. Dienel defines these panels as "groups of citizens who are selected by a random process and are given paid leave from their workday obligations for a limited period of time in order to work out solutions for given, soluble planning problems with the assistance of advisors on procedure" (Dienel 1980). Each panel includes 20 to 25 individuals who work on a predefined task in a group process. In order to encourage them to participate they are assigned the highly estimated role of a "value consultant" in the public planning process. The characteristics of citizen panels are illustrated in Table 3.

Table 3: Conditional Characteristics of citizen panels

STRUCTURE	CONDITION
Composition	Random selection of directly and indirectly affected citizens Involvement of stakeholders and public officials as witnesses, not as participants
Tasks	Evaluation of different decision options in accordance with personal values and preferences Clear political mandate to draft recommendations for legal decision makers
Operation	Continuous meeting over several days Education process of participants about likely consequences of each option Incorporation of uncertainty and dissent through public hearings and videotapes
Roles of Participants	Identification of participants as "value consultants" Need for an external, neutral, and unbiased facilitator Low involvement of sponsor (confined to witness role similar to stakeholders)
Organization	Payment of an honorarium to each participant for working as a value consultant Oversight committee for supervising the whole process and guaranteeing its integrity

Source: Dienel 1980.

Citizen panels are organized in three major components: (i) reception of information by lectures, field tours, videos, written material and other; (ii) processing of information in small group discussions, plenary sessions, and hearings; and (iii) evaluation of impacts of options in small group discussions, personal judgements and consensus-building exercises in the plenary. Informing the participants about the planning options and their likely consequences is the most vital part of the whole procedure. The major requirement is that all expert camps are equally represented in the information package and that they are allowed to present their own case. For example, if a citizen panel is hold to let people assess different kinds of energy supply systems, they are informed about the sources of energy, energy technologies, possibilities of energy conservation etc. In that way, people get the opportunity to be informed and to ask questions for improving their understanding of the issue.

Citizen panels are used as a 'sounding board' to test different ideas, options and proposals or to examine the needs and values of the community for an issue at stake. The feedback from the panel participants may help to provide information and to develop options and recommendations for collective decision-making purposes. Furthermore, the panels help to identify important issues that require more intensive research and consulting. Because of such diverse application areas, the motivation to establish a citizen panel is widely spread: firstly, the citizen panel is an opportunity to understand why people have different preferences and why they express specific opinions or attitudes about problems. Secondly, citizen panels reflect a microcosm of the society as a whole and provide opportunities to include a large diversity of opinions, including minority groups. Thirdly, they can be organised in parallel or in defined time periods in order to consider regional differences or changes of citizen opinions over time. Fourthly, public officials usually cannot acquire sufficient information about citizens' preferences to make decisions that reflect the needs and values of a society. Citizen panels provide a reliable method to get to most of the public preferences as a result of an informed choice. Fifthly, if people are involved in decision-making processes they support decisions and develop a kind of ownership over the results of the official decision-making process.

5 The Concept of Social Compatibility used for a citizen expertise

In August 1982, the German Ministry of Research and Technology initiated a large research project to investigate the preferences of the German population in respect of four energy policy options developed by a parliamentary commission in 1979. The Government was interested in eliciting reliable information about the energy scenario that was most attractive to the population and about the basis on which the citizens would evaluate the policy options presented in each scenario. A research team of the Jülich Research Center in Germany conducted a three-year study to collect data on public preferences and to analyse the motivations and underlying reasons for the judgement process of evaluating the predefined energy scenarios. The study was designed in accordance with the three phases: value tree analysis, impact assessment and citizen panels.

1. Values and criteria to assess and evaluate energy options were identified by interviewing representatives of 13 major stakeholder groups in West Germany (Keeney et al. 1987). In total, the groups generated 141 criteria to evaluate energy policies.
2. Approximately 30 energy experts were asked to give their best scientific estimates for the performance of each energy scenario on each of the revealed criteria (Renn 1986). The social, political and psychological impacts were assessed by expert rating using the method of a Group Delphi; the technical, economic, environmental, and international impacts were assessed by independent sub-contractors, such as the Prognos Institute in Basel (Switzer-

land) and the Institute of Foreign Policies in Bonn (Germany).

3. The resulting profiles of each energy scenario were conveyed to randomly selected citizens for evaluation and comment (Dienel and Garbe 1985; Renn et al 1985). The major tasks of the panels were to review the assessments, include the participants' values, and to make policy recommendations in accordance with their preferences.

The study operated with 24 citizen panels (each including approximately 25 participants) drawn from seven communities in different parts of West Germany. The panel meetings were held in public buildings for four consecutive days. Naturally not all persons who were asked to take part in the procedure were able to attend. Around 20 percent of all invited persons participated.

The objective of the panel meetings was to elicit the preferences of the participants and to lead them to evaluate the different options by taking into account the best scientific estimates of the likely impacts of each option, the political judgements of stakeholder groups and their personal value judgements. The task for each participant was hence to rate each energy system according to the given criteria, to assign relative weights to each criterion and to come up with a balanced recommendation which energy scenario should be implemented to meet future energy demands.

In addition to a scenario "business as usual" (reference scenario) a research team developed three scenarios describing potential development options for shaping the energy future. The scenario constructors chose two end-points for their three scenarios: 2000 and 2030. Each of the three scenarios represents different political world-views on desirable energy policies. They were constructed in line with the main political worldviews in contemporary German society: The scenario "business as usual" is based on the assumption that all present trends continue to shape the future energy situation. The second scenario stands for a supply-based approach of placing more advanced energy production technologies such as nuclear power reactors in the economy. The third scenario reflects the vision of a sustainable energy path based on new conservation technologies and demand-driven policies. The fourth scenario captures the vision of a "green" society in which people change their behavioral patterns in addition to improved conservation technologies. This scenario is based on the assumption that global environmental problems are so serious that dramatic changes in human behavior towards lower end-energy use are necessary. These three scenarios were designed to capture the major positions of the observable public discussion by means of three models that, according to the stakeholders involved in the process, seem to dominate the public energy debate.

The scenarios were the basic options for the panel to evaluate. The participants had two opportunities for the assessment of the scenarios and energy systems:

1. The participants received the results of the value trees and the impact assessments;
2. The participants had the possibility to develop their own associations that could be used for the assessment of energy systems and policies.

For the assessment process, participants could use the joint value tree. This tree consisted of eight main criteria:

1. Economic costs. The 'cost aspect' refers to investments, which are necessary to supply energy. It also includes the cost of energy for the consumer and the present and future costs for investments in technological developments.

2. Security of supply. This criterion addresses the availability of energy and energy resources. Besides, it includes aspects such as flexibility and possible breakdowns of energy systems.
3. Economic effects. This term refers to effects on the employment market and the economic structure.
4. Environmental effects. The 'environmental effects' involve environmental damages on water, air, soil and climate on a local, national and global level.
5. Health and security. The terms 'health and security' are taken together because they are associated with the same good. The criterion focuses on possible occupational and public health effects that might occur during the normal operation in the energy chain as a result of accidents or low safety precautions.
6. Social effects. With 'social effects' aspects like quality of work, income distribution, equity, standard of living or peaceful conflict resolution were included.
7. Political effects. The criterion 'political effects' incorporated aspects of political stability, freedom of action and political sovereignty.
8. International effects. The term 'international effects' refers to justice in the distribution of global resources and to the lack of resources due to international crises or war.

All participants of the citizen panel were asked to weigh those eight criteria according to their subjective importance and to develop recommendations in small groups of four or five people. During the four-day period, participants were asked to fill out questionnaires with standardized categories as a method to learn more about their reasoning.

5.1 Results of the Citizen Panel

A closer look on the results of the panel reveals that the most important criteria are all related to non-economic and non-material aspects. Over 35% of the participants decided that the criterion 'health and security' should be the most important criterion when assessing energy systems. The high importance of 'health and security' is attributed to the aspect that people are concerned about potential threats and health effects caused by energy systems. In particular the continuing discussion about nuclear energy and possible risks of this technology has probably contributed to the high weight given to this criterion. The second most important criterion for the assessment of energy systems was the criterion 'security of energy supply' (26%). Reasons for this might be the high dependence on oil resources and the concern about increasing energy prices. The third most important criterion, which was mentioned by the participants in the citizen panel, was 'effects on environment' (19%). It is assumed that the need of an intact environment and the awareness of environmental threats caused by technological systems are very important in citizens' decision-making processes[9].

The three most important criteria 'health and security', 'security of energy supply' and 'environmental effects' show that non-material aspects are the most important criteria for the panellists in assessing energy systems. Neither cost nor other related economic aspects were rated as similarly important. Due to the relative low weighting by the panellists, the problem of high costs seems to be less pronounced than it seems to be in actual policy making circles.

When asked for free associations linked to the evaluation of energy systems and scenarios, the participants rated 'guarantee of peace' the highest (70%), followed by 'employment guarantee' (68%), 'environmental protection' (42%) and 'citizen participation in decision-

[9] For further information see Dienel/Garbe 1985: 77ff.

making processes' (34%)[10]. This, again, is an indicator that people prefer non-material arguments when they are asked for their basis of evaluating energy systems.

The study demonstrated that citizens are able to assess complex issues such as energy systems. Also, it proved to be helpful for policy makers to learn about citizens' values for decisions, because the emphasis the citizens put on non-material values was surprising to most of the policy makers. To consider social values in decision-making processes, it is important to have methods such as citizen panels in place and not to rely on anecdotal evidence or non-reflected opinion poll results. Especially for such difficult decisions such as investing in a new energy system, citizens need to be involved in the process because if, for example, a new power plant will be built and citizens do not agree with the decision, they can initiate a strong movement against the technology. This can be avoided if politicians and experts take into account the "desirable circumstances in a society" (Renn et al. 1985: 56).

The concept of social compatibility and the use of participative research methods have demonstrated that social indicators need to be derived in a procedural and participatory way. Only by using such a method, values and attitudes of citizens can become visible and productive for future decision-making processes.

The preceding chapters provided information about the problems of the theoretical and empirical contents of social indicators. It was shown that social indicators can not – or only in a very difficult way – be derived from theoretical models since these do not claim universal validity. Thus, participative discourse processes were suggested for the development of social indicators. The advantage of this procedure is that the citizens are involved in the development of values, which are commonly regarded as being socially worth striving for. These values function as the frame model for the development of social

[10] For further information see Dienel/Garbe 1985: 86ff.

indicators, as it was shown in the concept of social compatibility in particular.

The opportunity to carry out a participative discourse process is not given for the development of the social indicators in our project. The development of social indicators – as presented in the following chapters – refers to a process consisting of several steps: Firstly, we scanned the latest literature for social indicators and collected them. Secondly, the collected indicators were checked for their suitability within the NEEDS project and its aim to measure "full costs and benefits of energy systems and energy politics". In a further selection, we orientated ourselves at the aforesaid concept of the social compatibility and its resulting social values. This means that social indicators will be developed for and assigned to energy systems based on the criteria which were analysed as being absolutely necessary and important for the society within the discourse process of the Jülich research team.

6 The development of social indicators for the evaluation of energy systems: The selection of social indicators

The collection of already existing social indicators was carried out by a literature and desktop research. The literature research was based on the information system of the academic libraries in South-West-Germany and on the information system of public libraries. We looked for publications - books, newspapers, magazines and journals - referring to sustainability and energy that were published within the last twenty years. For the search procedure we used the following keywords "social indicator", "sustainability", "environmental indicator" and "energy indicator", both in English and German. As a result of this search process we found about 1320 different indicators[11]. All indicators and criteria were tested to reveal their accordance with a set of meta-criteria for quality. Those meta-criteria were:

1. The indicators dispose of the characteristic of clarity. Does each suggested indicator present a clear, measurable entity or state of affairs? Does the criterion refer to aspects that can be indirectly operationalized by different kinds of indicators? For example, 'health' can be operationalized by different indicators such as the 'average life-expectancy' or the 'number of people with allergic reactions' etc., but an indicator measuring "health" in a direct way cannot be found. Therefore, aspects, which cannot be measured on

[11] The social indicator-set of the ‚Zentrum für Umfragen, Methoden und Analysen' works with more than 3000 time series (for further information see: ZUMA 2004).

their own, need to refer to observable facts that are measured with indicators.

2. The indicators are simple and logical. Are all indicators accompanied by a clear objective for the measurement? Are the criteria logically linked to the operational indicators and is there a clear measurement rule that defines units and yardsticks?
3. The indicators can be applied throughout Europe. It is the aim of the NEEDS project to assess the external costs of energy systems for the European Union as a whole. Therefore it is important that all indicators can be used in the European countries and are not only related to specific regional aspects. So, we defined as an important criterion of quality of the indicator that it can be applied in all European countries.

After collecting the existing social and energy indicators by key words, the collected indicators have been categorized into new classification schemes (see tables 4-6). This scheme did not refer to any theoretical considerations and served only as an overview of all collected indicators. Since indicators always belong to certain facts or values and show them in an empirical way, we have tried to develop an overview of the dimensions that are shown by the indicators by splitting up the indicators into the prevailing schemes. The schemes distinguish between indicators that relate to the main criteria of 'societal' aspects and 'environmental' aspects, and indicators that are related to the main criterion 'energy' aspects. In addition to these three main criteria, we developed sub-criteria which we assumed to cover all dimensions of the collected indicators. As mentioned above, those subcriteria do not relate to any theoretical background or concept. They were inferred from the main indicators on the basis of existing proposals for indicators. For example, the criterion 'financial and material expenditure' was included because we found in the literature indicators referring to financial situations, such as 'share of the effective electricity costs in a social welfare receiver budget' or 'poverty gap'. We also identified many environmental-related indicators in the literature, which highlighted different aspects of environmental quality. Examples are indicators such as the 'number of communities' that document the progress or regress in sustainable development on the basis of indicator measurements or the 'environmental quality index'. The first one belongs to the criterion 'sustainability' the second one was allocated in the category 'environmental effects'.

The subcriteria of the energy sector are related to the concept of energy indicators for sustainable development, which were defined by the International Atomic Energy Agency (IAEA: 2005). In our scheme, all criteria are expressions of the consequences of the production and the use of energy, as they have been defined by the IAEA (see table 6).

Table 4: Categories for criteria related to societal aspects

Societal aspects		
• financial and material expenditure	• supply guarantee	• job effects
• policy issues	• safety	• technical accessibility
• education	• risk	• acceptability
• welfare	• population growth	• health effects
• participation opportunity		

Source: own considerations.

Table 5: Categories for criteria related to environmental aspects

Environmental aspects		
• sustainability	• Agenda 21	• environmental effects
• environmental policy issues	• environmental-friendly activities	• pollution
• effect on long term resources		

Source: own considerations.

Table 6: Categories for the indicators related to the energy sector

Energy sector		
• energy efficiency of energy conversion and distribution	• energy prices	• energy use
• renewable energy	• waste	• energy intensity

Source: IAEA 2005: 5ff.

After the categorization into the categories of 'environmental', 'societal' and 'energy sector' aspects we checked whether the indicators that we found through the literature research combined social and energy aspects. Our interest, of course, lies in the identification of indicators that measure social impacts as a result of using different energy options. Unfortunately, only few indicators that we identified through the literature research measure related social impacts to energy systems. In general, social indicators deal with problems like income, education, demographic structure, health and culture. On the other hand, most of the energy indicators are related to issues such as energy consumption and new technological developments in the energy sector. Consequentially, the intersection between energy indicators and social indicators is small. As a result, only 148 of the 1320 indicators we found met our criterion of linking social aspects to the use of energy systems. These indicators can be found in the appendix.

In a further step, the 148 collected social indicators have been checked for their suitability within the aims of the NEEDS project. This check took place according to three main criteria. On the one hand, we had to ask ourselves whether the indicators had been suitable enough to check technologies of the future. This step is important because it is the task of the NEEDS project to evaluate external costs of energy systems at present and for the future. Addressing future, prospects turned out to be especially problematic for social indicators because most of the social indicators relate to perceptions and attitudes that are usually measured for a current state[12]. Many indicators did not meet this test. The next test referred to the question whether all indicators could be generalised for all of the European countries or if they were only of local importance. As our project-work is devoted to social aspects of energy systems in the whole of Europe, it was necessary to check the indicators for their regional specification and if necessary, to decimate those indicators that are only of local importance. The last test referred to the technology specificity of the social indicators. It was important to make sure that all selected indicators are technology-specific and able to discriminate between different kinds of technologies. As the objective of the NEEDS Project is to evaluate

[12] Those indicators might quantify future technologies in different kinds of ways. First of all, there is the possibility to ask today's young generation in the age between 16 and 20 years about their attitudes and values they have got today. It is assumed, that the attitudes and values of this young persons are firm until they are in the age of 30 or 40 years. In this age, people are in positions, in which they bear responsibility for their decisions and actions.

Another way to measure attitudes and perceptions for future technologies, relates to scenarios. In this method, people are confronted with models about the possible energy situation of the future. For the scenario building, general frameworks are postulated and the scenarios are built in relation to those frameworks. After the scenario building, people are asked to evaluate future technologies on the basis of the scenarios.

the full costs and benefits of different kinds of energy systems and energy policies, this is an essential criterion. To make sure that the collected indicators fulfil all these aspects, the selection was made in a case-by-case procedure. This means, each single indicator was checked whether it applied to all European countries, whether it could be quantified for future-technologies and whether it discriminated between technologies and applications.

The result of this process was that only a few indicators survived this testing method. So we added other indicators that we did not find in the literature but seemed to represent important social aspects. Such important social aspects refer, for example, to political stability and legitimacy or social components of risks. These new indicators could be found in the Jülich social compatibility study but also in studies on risk and benefit perception of technologies[13]. These studies show that individuals do not primarily assess risks on the basis of their probability, which is an important parameter for scientists and experts, but on the basis of qualitative characteristics, such as catastrophic potential or familiarity, when assessing risks. Furthermore, the emphasis on political stability in the Jülich study confirmed our view that a political culture, in which people have the opportunity to participate in political decision-making processes, was appreciated by most groups and seemed to be a prerogative for political stability[14].

Combining the social indicators, which we have found in the literature, and the new indicators derived from empirical studies on citizen preferences and risk perceptions, we ended up having 26 indicators that met all test criteria. The indicators were allocated to four main criteria that summarise the intentions of related indicators. The criteria correspond to the concept of social compatibility (Häfele/Münch/Renn 1985) that was described in section 5. As pointed out above, these criteria had been developed on the basis of

[13] For further information see: Jungermann, H./Slovic, P. (1993); Slovic (2000): Chrakteristika individueller Risikowahrnehmung.

[14] Renn et al 1985.

citizens' values. They represent the desirable state of the society as influenced by energy choices. The citizens emphasised values such as 'security of energy supply', 'financial and material costs of the energy chain', 'environmental effects', 'international' and 'social effects', 'health and security', 'policy' and 'economic' effects. For the NEEDS project we have considered and taken over nearly all criteria of this concept although we have reformulated some criteria for a better understanding of the dimension they rely on. Therefore, we developed the following criteria (see all criteria and Indicator in the indicator-set in the appendix):

Criterion 1: security/reliability of energy provision

This criterion refers to the stability of the energy system and points out the importance of the security of supply for every person and society. In our opinion, the consideration of four aspects can test the safety of the energy supply: On the one hand the question arises whether energy reserve capacities are needed. On the other hand the diversity of the energy supplier will be discussed. Therefore, an indicator was developed which explores the "market concentration in the supply or primary sources of energy". The consideration of this aspect is important because a high market concentration of energy suppliers in the primary energy sector could cause possible lacks in the energy supply if unexpected problems occur (e.g. technical damages etc). Beside those indicators that are directly linked with the aspect of energy suppliers, indicators were developed that focus on energy resources and the use of these resources. So we asked for the "time span for known reserves and assumed resources for each energy system if used at present rate" because a long-term energy supply depends also on the available resources and energy reserves. Furthermore, we raised the question about management concepts for waste and developed the indicator "probability of the not-in-time availability of a complete waste management concept". Consequently, the criterion „security/reliability of energy provision" is to be discussed on the basis of the following specific subcriteria:

a) system availability on demand
b) diversity of energy suppliers
c) reserves and resources and
d) waste management.

As a subcriterion of the security and reliability of energy provision we focus on the „flexibility and adaptability of energy systems“. This criterion refers to the ability of a system to be responsive to changes of price at the supply and demand side or technological developments in the energy field. We discuss this aspect by using the indicator "system flexibility to react to market changes, in particular sudden fuel price fluctuations". Just in the current market situation that is characterised by raising oil prices and an increasing energy demand on the Asian market, flexible reactions on changing market situations become important. Beside the market flexibility, the flexibility of the energy systems can also be seen in the reactions on technological developments and breakdowns. Therefore we implemented into our set of social indicators the indicator "flexibility to incorporate new technological developments and breakthroughs”.

Criterion 2: Political stability and legitimacy

These two closely related criteria include the need of participative decision-making processes for different kinds of technologies or the availability of peaceful procedures to resolve technology-induced conflicts. Such conflicts might arise if the acceptability of energy systems or political decisions is perceived as low. Often the acceptability is low because citizens do not recognize their own values in political decisions and do not understand the reasons for different kinds of decisions. Therefore, we developed four subcriteria to cover the political stability and legitimacy. Those criteria are:

a) the potential of social conflicts induced by energy systems

b) the willingness of people to act (mobilization potential)
c) the reliance on participative decision-making processes and actually
d) citizens' acceptance of energy systems.

The first subcriterion, the potential of conflicts, induced by energy systems, will be measured by conflicts that are based on historical evidence. The potential of mobilization will be measured by the indicator "willingness of NGOs and other citizen movements to act for or against the realisation of an option". This indicator considers not only the willingness to act but also the whole extent of actions. For example, the resistance against specific power plants might occur on regional, national and cross-national levels. Due to the fact that a strong movement against power plants might endanger the political stability, this indicator has to be involved. The indicator "reliance on participative decision-making processes" refers to the necessity of the accomplishment of participative decision procedures. This indicator discriminates strongly between different kinds of energy technology. It can be said that citizens like to be involved when politicians decide to build a new nuclear power plant, but against the building of solar power plants (until now) no citizen movements have been seen. Nuclear power plants bear for citizens a higher risk potential, which also affects the acceptance of the technology. The indicator „empirical survey results about citizens' acceptance of the power plant" will consider this aspect. A lot of surveys have dealt with this question and their results can be used in our project.

Criterion 3: Social and individual risks

In this case we differentiate between subjective and objective social risks. Terrorist threats are also handled in this category but this subject is only seen from an objective side. Subjective social risks are such risks that individuals perceive. The perception of those risks is often influenced by qualitative risk characteristics such as personal control, familiarity or equitable distribution of risks and benefits. Beside those psychometric variables we ask citizens after their subjectively expected health consequences from normal operations at the energy system. This indicator includes the “worst case scenario” that can occur in case of accidents in the energy system. If such accidents will happen or not also depends on the risk management and safety arrangements. Therefore, we raise the question if people trust in risk management or not. This indicator does not only rely on the safety arrangements of a power plant, it also involves citizens’ trust in public and private risk management agencies. To sum it up, the criterion “subjective risk estimates” is discussed in three main aspects:

a) the perceived risk characteristics for accidents. Those are psychometric variables like the personal control
b) the perceived risk characteristics for normal operation and
c) trust in risk management.

On the objective side, we define risks according to statistically measured health effects from normal operation and accidents. While survey data and other social science instruments measure subjective risks, objective risks are measured by empirical data through statistical forms of analysis. Therefore, we rely on the indicators “mortality due to normal operation” and “mortality due to severe accidents”.

In order to completely cover the criterion of social risks, it is necessary to consider the risks perceived from a subjective point of view as well as the risks, which are objectively comprehensible - those risks that refer to terrorist threats. In our set of indicators, we have established the aspect of terrorist risks as an objective criterion. For example, we ask for the risk potential of a successful attack that is assigned by experts to certain power plants. This indicator considers the argumentation that a successful attack on a nuclear power plant, for example, would result in catastrophic consequences. On the other hand, the indicator also considers that, due to high security precautions, an attack is hardly possible. Thus, not every technology consisting itself of a high extent of damage also consists of a high terrorist potential. Nevertheless, it also might happen that a successful attack takes place. Thus, we also enquire about the “maximum potential effects of a successful attack”. In doing so, we also consider damages for the environment as well as personal damages (evacuated people, deaths, etc.).

Criterion 4: Quality of Life

The criterion “quality of life” is a very common one, which can be split up into two categories:

a) social compatible development and
b) effects on the quality of landscape area.

A social compatible development, which can be derived from energy systems, will be measured on the basis of three specific indicators. Firstly, the “share of the effective electricity costs in a social welfare receiver budget” is determined. This indicator aims at the financial charge persons that receive a public income support have to pay due to electricity costs. According to statistics, the kilowatt hour for power can be produced at different prices depending on the technology. The mentioned indicator takes into account this aspect and the financial charge. Secondly, the indicator “technology specific job opportunity” determines the professional opportunities in the energy sector. Thirdly, the indicator “perception of the fairness of the distribution of risks and benefits of the energy facility in the neighbouring communities” aims at the subjective fairness evaluation of the citizens with regard to the advantages and risks of energy systems. For example, citizens might consider it as unfair if close to their residence area gas pipelines are laid although they are not supplied from this station.

The "effects on the quality landscape area" will be determined on the basis of six different subcategories and their accompanying indicators. For example, the restriction of rural areas is considered by determining the area, which is needed for the energy systems. Furthermore, the impairment of public areas is analysed. The indicator "inaccessible public area because of energy systems" determines to what extent public areas are blocked by cables, buildings, pipelines or machines. Besides from this, negative effects on the quality of one's home will be discussed. This impairment is determined on the basis of the aspects noise, aesthetics, traffic and, finally, citizens' satisfaction with the power plant. To measure the importance of aesthetic aspects, the indicator "part of the population that perceives an aesthetic impairment of the landscape area which is caused by the power plant" has been developed. Besides, the indicator "number of residents feeling highly affected by noise caused by the energy facility or transports to and from the energy facility" has been developed. It focuses on the aspect of noise. Referring to different energy technologies, this indicator might mainly give information about the noise pollution e.g. of wind energy plants situated close to local residents. However, other energy technologies also face the problem of being the reason for a partly high noise pollution. Especially arriving and leaving trucks, which transport material to and from the power plants, can be mentioned as reasons for noise. Arriving trucks can also be the reasons for traffic jams. In order to not neglect this aspect, the indicator "contribution to congestion in traffic peak periods through transports to energy facility" has been developed and implemented. How much residents are subjectively satisfied with the power plants serves as a kind of summary of most of the mentioned indicators. To what extent local residents are satisfied with the power plant might depend on various aspects, as the risk potential, the noise pollution, professional opportunities or the aesthetic impairment. In order to implement a criterion summarizing all these aspects, the indicator "subjective satisfaction of the inhabitants with the power plant" has been developed.

Those mentioned criteria and indicators build the basis of our social indicator-set. In a further step of the project those indicators will be measured in reference to the four main life cycle phases of energy systems: energy extraction and processing, transport, power plant (conversion to electricity) and waste management (considering the entire back-end). An ordinal scale will measure most of the selected social indicators. In measurement theory, the term 'ordinal' means that researchers establish an order between the elements of the scale by assigning ascending or descending numbers to each element without specifying the exact distance between the scale points. For example, if people are asked about their perceived risk potential of energy systems, they have to mark on the ordinal scale one of 4 categories, like: 4 – "high risk potential", 3 – "middle risk potential", 2 – "low risk potential", 1 – "no risk potential". The distances between the four categories are not equal and therefore cannot be interpreted as if the number would represent an interval scale. If researchers know exactly the distance between scale points, they talk about 'interval scales' or even 'ratio-scales' when the scale has a natural zero point (like a metre rule). There are also nominal scales where researchers can only say that there is a difference but without a ranking. Gender, for example, is on a nominal scale, men and women are different, but it cannot be said, that the one is ranked higher than the other.

7 The Delphi method

According to the project work, which has been done so far, the next step was the preparation of a Delphi. The Delphi was carried out to get the final set of social indicators. Therefore stakeholders had to evaluate and discuss the set of indicators, which we had developed.

The Delphi method is a scientific process, which helps to get arguments and patterns for decision-making processes. The outcome of a Group Delphi is a clear distribution of patterns and new arguments for diverged positions. For the NEEDS project the Delphi was prepared to get an evaluation of the collected social indicators by stakeholders. The Delphi method that was used in the NEEDS project is a further development of the classical Delphi, which was developed by Rand and Co. in the 1960s. At that time, the Delphi was used to evaluate defence technologies and weapons, later it was used within the technological assessment. The Delphi concept contains the following steps:

1. A questionnaire is prepared by the research team. The questionnaire contains questions about the expected consequences of a stimulus (for example environmental standards) and is send to stakeholders. Apart from the questions concerning the stimulus, the subjective certainty in answering the questions is asked.
2. After filling in the questionnaire, the stakeholders send the questionnaire back to the research team, which has made the questionnaire. The research team evaluates the statements in the questionnaires and calculates statistical data for every question such as the mean values or variances. Also they check the stakeholders' certainty while answering the questions. Those subjective (un)certainties can be used for weighting of the results.
3. The original questionnaire and the analysis from the primary questionnaire is sent back to the stakeholders. In this case, all

names of the stakeholders are treated anonymously and the stakeholders are asked to fill in the questionnaire once again but this time in consideration of the results of the primary questionnaire. The aim of this second step is, to reduce the variances of replies and to raise the collective certainty in answering the questions.

4. Steps 2 and 3 are repeated until the stakeholders have no more changes to add. As a result of this iterative survey the frequency of the replies shifts either to a normal distribution (that's the case when all stakeholders who have taken part in the survey agree on the same statements) or the frequencies are split into different distributions. This might be the case, if there are two or more different points of view that cannot come to an agreement.

For the NEEDS project, a variation of the classic Delphi was employed called Group Delphi (Webler et al. 1991). The major objective of a Group Delphi is to divide a group of experts (in the case of the NEEDS project, stakeholders were invited instead of experts) into small working groups, to compare the judgements of these groups in a plenary session, and to identify the areas of uncertainty and dissent among the experts. The more one of the groups' ratings deviate from the median of all other groups the more time is allocated to this group to defend and substantiate its judgement. This justification procedure assures that relevant information is shared among the participants so that differences in evaluations are not based on ignorance but on different interpretations of the existing data. There is a direct testing for dissent in a "peer review" process. In addition, the Group Delphi produces not only numerical values and distributions, but also verbal explanations for deviations from the median.

Each round contributes to the clarification of the issues and leads either to a consensus or the formation of dissenting camps with diverging views and corresponding argumentation. The typical sequence of a Group Delphi is shown in Table 7.

A Group Delphi encompasses the traditional elements of the conventional Delphi such as feedback of responses into the successive round, assessment of group judgement and opportunity for participants to revise their views, but anonymity is not preserved. Another difference between the Group Delphi and the conventional Delphi is the time. The Group Delphi is accomplished in one or two days whereas the conventional Delphi may take several months. In spite of these two specific shortcomings of the Group Delphi process, it provides three major advantages that are not offered by the traditional Delphi method.

1. It produces a clearer picture of the dissension among the expert panel.
2. It requires justification for the dissent.
3. It provides direct testing of dissent in a peer review.

As a technique to reduce uncertainty, the Group Delphi is successful. It is an example how the conventional Delphi can be altered to include verbal explanations for different points of and establish a common level of background knowledge among the experts participating in the event.

Table 7: Sequence of a Group Delphi

STEP	DESCRIPTION
1. Development of the Questionnaire	Based on the criteria and options, a numerical scale should be developed that is best suited to elicit expert judgements on the performance of each option on each criterion.
2. Selection of Experts	Selection of experts with different points of view about the subject who represent relevant, but diverse disciplines.
3. First Plenary Session	Introduction into the Group Delphi process and the question at issue. The selection process of the options and the criteria is explained to the participants.
4. First Group Session	All participants are randomly divided into groups of 3-4 people. Each group is asked to complete the questionnaire. Group consensus is the goal, but minority votes are allowed.
5. Second Plenary Session	The results of the group assessments are handed out to all participants. The groups whose ratings deviated most from the median values of all groups are asked to defend their point of view in front of all participants. The defences are discussed in plenary (and taped for evaluation).
6. Second Group Session	The participants are divided in small groups again, this time according to the principle of systematic rotation. The groups are asked to complete the same questionnaire, taking into account what they learned in the plenary discussion.
7. Iteration of Plenary	Steps 5 and 6 are repeated until no further changes occur in the responses of groups or the positions of the participants are established and all arguments are exchanged.

8. Evaluation of Results	The ranges of the numerical results of the last round are taken as the best expert estimates for the impact analysis. The (video)tapes provide arguments and evidence for the final scale values or explain the distribution of expert opinions.
9. Validation	The results and the justifications are sent to all participants for final comments or further thoughts on the subject. In addition, the results can be peer-reviewed by other experts who did not participate in the process.

Source: Webler et al. 1991.

8 The NEEDS-Delphi

As mentioned above, sustainability in general and social sustainability in particular are no analytic concepts, which can claim to be value-free in the sense of neutral. They depend on an understanding of what is positive and what is negative for humans and for societies and this relies on value judgements, which cannot be done in a genuinely scientific procedure (Weber 1988). As a result, we checked whether our defined set of criteria and indicators was supported by the relevant stakeholders in the energy field. In order to do that, we organised an Expert Delphi, which was done in two phases. In the first phase, we asked stakeholders in the domain of energy economics and policy making to rate each of the criteria and indicators developed by the project team on appropriateness and suitability. They were also asked to decide which of the indicators should be included in the final selection. Based on our initial set, we composed a questionnaire, which was sent in November 2005 to 52 experts representing the different stakes in the energy sector, including industry and industry associations, political and administrative institutions, environmental groups, associations representing energy consumers, trade unions and scientists. They were asked to fulfil the following tasks:

1. Rate the adequacy and suitability of the criteria and indicators for the measurement of social effects of energy systems;
2. Give an estimation of their subjective confidence (in percent) in their own judgements;
3. Indicate whether the list of criteria and indicators needed to be complemented.

Although the experts had been selected because of their membership in stakeholder organisations, they participated in the process as individuals. So both the survey results and the Delphi-results did not correspond to institutional views. In total, 39 stakeholders filled in the questionnaire. The respondence rate of 75% is remarkably high. One major result is that the original set of criteria and indicators developed by the project team has been evaluated as being complete. A consistent trend to reduce specific criteria and indicators could not be observed in the outcome of the survey. There was no majority for the reduction of any part of the list.

In a second phase, a Delphi workshop was organised in January 2006. It took place on January 23rd and 24th. The participants of the Delphi were selected from the sample of the survey during phase 1 of the Delphi process. The decision to organize a two-day Delphi workshop instead of a one-day workshop was taken to reduce the risk that participants would not show up on time because of flight or train delays and cancellations caused by bad weather, a condition that is not unlikely in January. However, this decision increased the barriers for the participation and reduced the willingness to participate in the Delphi workshop. In particular, the representatives from industry were unable to attend a two-day-workshop. To increase the balance of interests during the Delphi-workshop, we decided to invite an industry representative who did not participate in the first round.

The Delphi-workshop was professionally moderated by Dr. Marion Dreyer from the DIALOGIK gGmbH in Stuttgart (http://www.dialogik-expert.de/en/). DIALOGIK has expertise and experience in the field of participatory processes and conducts systematic research on practical forms of communication and cooperation in the conflict-laden triangle of politics, economy and civil society.

The Delphi-workshop was attended by eleven participants, who came from the following stakeholder groups (the numbers are in brackets): industry (2), economic research (1), energy research (2), trade unions (1), political and administrative institutions (2), NGOs (2), others (1). Running the Delphi-workshop we were faced with two problems: One representative from industry could only join the Delphi-workshop for one day and one representative from political and administrative institutions and one NGO-representative were not external observers of the project, but related to the project and thus certainly more involved in the results than other participants.

As described above (see table 7), the Delphi-workshop consisted of several stages. The group came to a consensus about the general structure of criteria and indicators after two rounds of group and plenary discussion. Every participant agreed to the structure of indicators that finally evolved after the two rounds. Compared to the initial structure, the Expert Delphi suggested a minor but essential modification to the structure of criteria and indicators.

Table 8: Results of the Delphi meeting in Brussels (23rd/24th of January 2006)

Criterion	Indicator
Continuity of energy systems over time	reliability of energy supply (short and long term perspectives, internal aspect)
	vulnerability of energy systems (short and long term perspectives; external aspect)
Flexibility and adaptation of energy systems	flexibility to incorporate new technologies
Institutionalised participatory decision-making processes	conflicts induced by energy systems
	citizens' perception of risk and benefits
Objective risk assessment	Morbidity due to normal operation
	Effects of catastrophic events
Socially compatible development	technology specific job opportunities
	share of electricity costs for low income households
Social and environmental amenities	land use caused by energy systems
	probability of the timely availability of decommission and waste management
	population affected by emissions of energy systems

Source: results of the NEEDS-Delphi in Brussels. Own consideration.

Comparing Table 8 with Table 9, we can see that no criterion or indicator had been added to the originally proposed structure, but that there are some shifts in weight as a result of the Delphi-process. Some criteria and indicators were evaluated as more important than others.

The participants of the Delphi agreed that the stability of the energy supply is a crucial factor. They distinguished two different aspects that determine the stability of the supply, the reliability of the energy supply, which represents the internal dimension of the energy system, and the vulnerability of the energy system, which represents the external aspect. While the internal aspect is mostly related to energy production, the external aspect also addresses other aspects of the energy system such as the distribution and grid system.

Regarding the criterion "flexibility and adaptation of energy systems", the Delphi participants assigned a high weight to flexibility with respect to innovation and new technologies. This was regarded as being more important then the flexibility to respond to changing market signals.

Regarding the conflict dimension, a re-naming of the criterion was suggested. The new criterion was called: institutionalised participatory decision-making processes. The most important indicators representing this criterion were "citizens' perception of risks and benefits" and "conflicts induced by energy systems".

The Delphi participants also came to the conclusion that the results of the objective risk assessment should have more weight in decision making than the subjective risk estimates by laypeople (risk perception). The most important indicators to measure risks are "morbidity due to normal operation" and "effects of catastrophic events". At the same time, terrorist threats were not seen as being of equal importance.

Regarding the socially compatible development, the two indicators "technology specific job opportunities" and "the share of the electricity costs for low income households" were seen as important and suitable representations of this criterion. On the same criterion "social compatible development", the Delphi process led to some modifications. First, the title of the criterion was changed after long discussions into social and environmental amenities to indicate the subjective and emotional quality of landscape and residential area, too. The best indicators to measure this aspect included, according to the Expert-Delphi, "land use caused by the energy system", "probability of the timely availability of decommission and waste management" and "population affected by energy systems".

Having the results of the Delphi workshop, social scientists got the task to compare them to the original developed indicator-set and take into account the results of the Delphi meeting. Focusing on the fact, that a multi-criteria-analysis will encompass all dimensions of sustainability, the original 26 social criteria needed to be further condensed by employing a "ranking" procedure. This was done by taking into account three aspects:

First of all we focused on the recommendations of the Stakeholders and tried to rank the indicators. Furthermore, we made the ranking by heeding the availability of data and considered, of course, the feasibility of getting the data. The results of the ranking are presented in the next chapter.

9 The justification of the selected social indicators and their ranking

In the NEEDS project the full cost assessment of energy systems includes economic, ecologic and social aspects.

Referring to the social aspects, eight main criteria have been developed. These criteria are:

- Criterion 1: Continuity of energy service over time
- Criterion 2: Flexibility and adaptation
- Criterion 3: Political stability and legitimacy
- Criterion 4: Subjective risk estimates
- Criterion 5: Objective risk estimates
- Criterion 6: Terrorist threat
- Criterion 7: Socially compatible development
- Criterion 8: Effects on the quality of landscape and residential area

A total of 26 indicators have been generated to capture the extension of each criterion. As one input to a multi-criteria-analysis, that will encompass all dimensions of sustainability, the 26 criteria need to be further condensed by employing a "ranking" procedure. Out of the 26 indicators, 13 were selected to be very important for the assessment of energy systems and labelled with the priority number 1. Nine indicators were regarded as less important but still significant. They were assigned the priority number 2. Three indicators were regarded as complementary and could therefore be omitted from further analysis. These indicators received the priority number 3.

What were the rationales for making these priority assignments? The following paragraphs provide some explanation for the selection. The priority numbers are listed in brackets.

Criterion 1: Continuity of energy service over time

- Need of reserve capacity (2)
- Market concentration in the supply of primary sources of energy (2)
- Time span for known reserves and assumed resources for each energy system if used at present rate (1)
- Probability of the not-in-time availability of a complete waste management concept (1)

The criterion "continuity of the energy service over time" was judged very important for the overall assessment of energy service. Having energy services available over time is the basis for securing energy supply. This criterion includes the assessment of reserve capacity and the time span for known and assumed resources. In industrialised countries prevalent commercial energy sources such as coal, gas, atomic energy, hydro and mineral oil are not renewable and have a limited life span.

In 2002, commercial energy consumption in the European Union was 3,32 T crude oil per inhabitant[15] . From 1999 till 2004 the final energy consumption caused by European services and households was increasing[16]. The reasoning might be that more and more domestic ap-

[15] Statistisches Bundesamt 2004. Furthermore, see for the figures of primary energy resources: BP 03, June 2003; for the figures of population: UN, World Population Prospects, The 2002 Revision; Eurostat, Databank New Cronos; Taiwan: Statistical Databook 2003.

[16] European Commission 2006: energy statistics 2004.

pliances are used, and industrial production procedures are becoming more and more reliant upon electricity driven devices (this refers only to electricity).

The first indicator "need for reserve capacity" covers the strategy of European countries to have a sufficient amount of primary energy stored if there is a shortage or even a disruption of supply. In addition, the indicator includes the installation of extra capacity in converting primary energy to secondary energy and energy services. This indicator was regarded as important, but may be less significant than the diversity of supply and the importance of the physical time span for known reserves. Therefore it was assigned the priority number 2.

The indicator "market concentration in the supply of primary sources of energy" refers to three potential problems: First, a high market concentration of an energy supplier in the primary energy sector could cause possible shortages in the energy supply if unexpected problems occur (for example, technical damages, etc.). Second, concentration may lead to monopolistic pricing of energy. It can be demonstrated for the electricity and gas sector that a lack of business competition within the European Union leads to increases in price that cannot solely be explained by cost development. Third, reliance on a few or even one supplier(s) for primary energy may increase the dependence on supplier company or supplier countries with many uncertainties about political stability and market dominance. Energy supply depends more and more on regions that are politically unstable[17]. Although this indicator refers to an important aspect of energy security, it has been assigned priority number 2 as a part of this indicator is already covered in the indicator "time span for known reserves".

The indicator "time span for known reserves and assumed resources for each energy system if used at present rate" describes the physical as well as economic availability of primary energy sources. It is self-

[17] See Prognos 2000.

evident that this indicator is essential for judging the continuity of energy services over time. Therefore it was assigned primary importance (1).

The indicator "probability of the not-in-time availability of a complete waste management concept" refers primarily to nuclear power plants and addresses the problem of waste disposal of fuel assemblies. At the present time, a concept for the final disposal of spent fuel assemblies is still missing; at present, nuclear waste is mostly stored at the reactor site or in intermediate facilities[18]. This indicator was judged as very important as it is central in the nuclear debate all over Europe and determines much of the nuclear policy throughout Europe.

For the measurement of the criterion "continuity of energy service over time", all four of these indictors are important. Since the request has been to choose and minimize the number of indicators, we assigned the indicator "market concentration in the supply of primary sources of energy" and "need for reserve capacity" a lower weight, as we think that the continuity of energy service over time can also be guaranteed if reserve capacity is limited and the market is dominated by a few energy suppliers. The assumption here is, however, that supplier countries are experiencing political stability.

Criterion 2: Flexibility and adaptation

- System flexibility to react to market changes, in particular sudden fuel price fluctuations (2)
- Flexibility to incorporate new technological developments and breakthroughs (1)

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[18] For further information see also European Environmental Agency 2003, International Atomic Energy Agency 2004.

Criterion 2 refers to the ability of energy systems to react to new technological developments and market changes. Concerning the European climate protection policies and the need for energy diversity[19] , the flexibility of the energy system is an issue of great importance. Flexibility in the energy sector is directly related to energy efficiency strategies, and provides an adequate approach to the challenges of energy markets in a global economy[20].

Since the NEEDS project focuses on new and sustainable energy strategies, the indicator "flexibility to incorporate new technological developments and breakthroughs" was given primary priority as it signals the degree of adaptability of energy systems. The incorporation of new technological developments can lead to more efficient and especially more sustainable energy production.

The indicator "system flexibility to react to market changes, in particular sudden fuel price fluctuations" is also important. But similar to the indicator "market concentration" this indicator is subordinate in comparison to the availability of new technological means of energy conversion, storage and transportation. Literature shows that the fluctuation of fuel prices has an impact on industry and the availability of energy. Sauter and Awerbuch suggest that even relatively small oil price increases cause sizeable economic losses[21]. At present, we witness a high increase of oil prices, thus this indicator might become more and more important. Nevertheless, under the pressure to assign priorities among indicators, the decision was to place this indicator in the second category.

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[19] See the EU sustainable development agenda/Gothenburg strategy. Furthermore: the interview with Jacqueline McGlade, Director of the European Environment Agency (EEA). The interview was given on March 14th 2005 to EURACTIV. Also: http://www.euractiv.com/en/environment/sustainable-development-eu-strategy/article-117544

[20] See for example: Wuppertal Institut 2005.

[21] Sauter/Awerbuch 2003.

Criterion 3: Political stability and legitimacy

- Potential of energy system induced conflicts that may endanger the cohesion of societies (2)
- Willingness of NGOs and other citizen movements to act for or against the realisation of an option (2)
- Reliance on participative decision-making processes for different kinds of technologies. (3)
- Empirical survey results about citizens' acceptance of the power plant (1)

For the ranking of these four indicators, we referred to the feedback provided by the stakeholders consulted in a stakeholder Delphi procedure in January 2006 in Brussels. The Delphi participants had rated the understanding of citizens' acceptance of different kinds of power plants which is essential for the measurement of political stability and legitimacy of an energy system. If citizens do not accept the respective power plant, they might initiate actions to oppose this facility. The resulting conflict potential can be expressed by protests and demonstrations or even in violent acts by citizen movements or NGOs. Such movements can threaten the political stability and legitimacy of political decisions.

Scientific studies suggest that wind power stations and nuclear power plants are considered most controversial by citizens when compared to fossil or renewable energy facilities[22]. To construct a reliable and valid database, it is desirable to conduct empirical sur-

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[22] See for example:

FORSA 2004: Meinung zu Windenergie.

Interreg III-C/WindTechKnow 2005: Regional Wind Technology And Knowledge Transfer Strategies.

Renn, O./ Zwick, M. 1997: Risiko und Technikakzeptanz.

Renn, O. 1984: Risikowahrnehmung der Kernenergie.

veys about citizens' acceptance of different types of power generation. The acceptance of power plants is also a key indicator for the conflict potential that may be induced by energy systems.

The two indicators "Potential of energy system induced conflicts that may endanger the cohesion of societies" and "Willingness of NGOs and other citizen movements to act for or against the realisation of an option" are measuring the same dimension as the acceptance indicator, i.e. the mobilisation potential of individuals and groups with respect to different means of energy production. One is more related to the characteristics of energy systems that trigger mobilisation, the other one relates to organisations and their evaluation of energy systems. Since both indicators are highly correlated with individual acceptance they were assigned second priority. It should be noted, however, that individual acceptance does not determine collective mobilisation potential. It is rather a necessary but not sufficient condition for political protest. If organisations or groups do not place the issue on their agenda, individual lack of acceptance has hardly any resonance in society.

The last indicator "Reliance on participative decision making processes for different kinds of technologies" is already largely covered by "Potential of energy system induced conflicts that may endanger the cohesion of societies". In addition, there is not enough data available for reaching meaningful conclusions. It is also not clear whether the need for more participative decision-making processes implies a positive or negative connotation. On the one hand, the need for more participative decision-making processes can be regarded as something positive because citizens are involved and empowered to co-determine their energy future, thus improving overall social cohesion. On the other hand, it can be argued that only controversial technologies need such participative processes so they should be avoided in the first place. Because of these ambiguities and the need for reducing the set of indicators, we recommend excluding this indicator from the multi-criteria assessment (assignment of 3).

Criterion 4: Subjective risk estimates

- Psychometric variables (personal control, catastrophic potential etc.) (1)
- Subjectively expected health consequences from normal operation (2)
- Trust in risk management (private and public agencies) (2)

The indicator "subjective risk estimates" covers the perception and evaluation of individuals and groups with respect to the risk of a given energy technology. It is known from literature that risk perception is a main driver for acceptance but also for social mobilization.

All three indicators promise to deliver interesting data. Since the indicator-set needs to be reduced, a priority assignment was also performed for this criterion. The indicator "Psychometric variables" received highest importance in our rating exercise. This indicator measures the reasons (other than expected health and environmental consequences) for differences in individual rating of risks. If individuals are asked for an evaluation of the seriousness of risk, the resulting judgement correlates highest with psychometric variables such as voluntariness, personal control, familiarity and others (in multiple regression analyses these independent variables demand the highest amount of declared variance).

In contrast, the indicator "subjectively expected health consequences from normal operation" is less important for the overall subjective risk estimate. It may be interesting to contrast the subjective with the statistical estimate but for the purpose of capturing risk perception the qualitative variables are more relevant than the single estimate of expected impacts. The same is true for trust: although most studies show that trust in institutions shape individuals judgements with respect to perceived seriousness of risk the correlations are rather modest for most risk sources. However, trust adds another dimension and may become a decisive factor if acceptance of technology is closely associated with perceived performance of organizations that manage or control these technologies (for example genetically modified organisms). People do protest against the construction of a power plant if they do not trust in the risk management of the operator or if they associate health and environmental impacts with the risk source. Yet both aspects are partially covered by the psychometric variables and indirectly addressed by the indicators of criterion 3.

Criterion 5: Objective risk estimates

- Mortality due to normal operation (reduced life-expectancy) (1)
- Mortality due to severe accidents (1)

This criterion refers to expert-based statistical or modelled data. For the assessment of energy systems, one needs to include both: the subjectively perceived as well as the expert-based estimations. Research has shown that the two estimates differ considerably depending on risk source and context[23]. Since both normal operation and accidents are equally important when assessing overall risks, one needs to assign both of them the same importance value. They both receive the importance rating of 1.

Criterion 6: Terrorist threat

- Potential for a successful attack (3)
- Maximum potential effects of a successful assault (1)

This aspect was included in the list of criteria to recognize the growing importance of terrorist attacks and sabotage for energy safety and security. It was isolated from the overall risk indicator because reli-

[23] See for example:

Slovic, P., Fischhoff, B., Lichtenstein 1980.

Slovic, P. 1987.

able models for calculating the probability distribution of terrorist attacks are not available.

The “maximum potential effects of a successful assault” indicator was ranked as particularly important to measure the potential of a terrorist threat. Terrorists choose their target for an assault to accomplish maximum damage. The maximum damage will obviously be the goal. Terrorists are likely to perform a trade-off between impact and effort. For example, the impact of attacking a nuclear power station may be considerable, at the same time the effort to release this impact is quite high. Since it is hard or even impossible to anticipate how terrorists will make this trade-off between impact and effort, one is on the safe side by choosing the maximum impact that can be accomplished with reasonable means. This is covered by the indicator “Maximum potential effects of a successful assault“. The second indicator “Potential for a successful attack” refers to the probability of choosing target 1 over target 2. As this indicator relies on speculation rather than empirical measurements, a priority rating of 3 seems to be justified.

Criterion 7: Socially compatible development

- Share of the effective electricity costs in a welfare receiver budget (1)
- Technology specific job opportunities (direct) (1)
- Perception of the fairness of the distribution of risks and benefits of the energy facility in the neighbouring communities (2)

Criterion 7 addresses the impacts of the different technology choices on socially highly estimated values such as equity, prosperity and employment. Since these values have high importance rankings in all surveys the overall importance of this criterion is undisputed.

For ranking the three indicators that were attributed to this criterion we referred once again to the aforementioned stakeholder Delphi procedure and its results. The stakeholders found it very important to include technology-specific job opportunities as would provide long-term employment possibilities. As employment tops the list of public concerns in almost all European countries, there is a compelling reason to assign the importance value of 1 to this indicator.

The stakeholders also recommended assigning high weight to the indicator "share of the effective electricity costs in a welfare receiver budget". This indicator includes two aspects: first, the relative share of energy costs in comparison with other costs of infrastructure, and an equity dimension by looking specifically at low-income groups in society. Since equity is addressed in this indicator, there is less need to consider the perception of equity. One should note, however, that similar to real and perceived risks the perception of equity may differ from the statistical data on the distribution of resources. Unlike risk perception, however, equity judgements have not such a direct impact on the judgement about energy technologies. For this reason an importance value of 2 has been assigned to this indicator.

Criterion 8: Effects on the quality of landscape and residential area

- Land use caused by energy system (1)
- Inaccessible public area because of the energy system (3)
- Part of the population that perceives an aesthetic impairment of the landscape area which is caused by the power plant (3)
- Subjective satisfaction of the inhabitants with the power plant (2)
- Number of residents feeling highly affected by noise caused by the energy facilities or transports to and from the energy facility (1)
- Contribution to congestion in traffic peak periods through transports to energy facility (1)

This criterion has a major impact on the judgements of the population in the vicinity of the energy generating facilities. Out of the six indicators, three were chosen as being most important for measuring the quality of the landscape and residential area. The indicator "land use caused by energy system" was selected because the land that is used for constructing facilities is lost for other purposes such as infrastructural development, agriculture, etc. Depending on the type of facility and the energy system, the amount und degree of land use may vary considerably[24]. The other two indicators that we assigned the importance value of 1 include impacts that have direct effects on residents. One indicator refers to the noise caused by the facility, including transportation, and the other aspect refers to the amount of traffic that can be caused by transports to and from the energy facility[25].

Three indicators were rated as less important in this respect: The indicator "Inaccessible public area because of the energy system" was rated 3 on the importance scale. Since much of the intention of this indicator is already covered by the indicator "land use" it was seen as less important for the inclusion in the multi-criteria analysis. The indicator "Part of the population that perceives an aesthetic impairment of the landscape area which is caused by the power plant" was seen as a subset to the indicator "Subjective satisfaction of the inhabitants with the power plant" (thus also receiving a 3 in the importance rating). This remaining indicator was assigned an importance weight of 2 since it is less decisive on social compatibility than land use or noise, yet it does include subjective factors such as aesthetics end emotional feeling about the facility that is not covered by any of the other indicators.

[24] See for more information for example: IPCC 1998: Special Report on Land Use, Land-Use Change And Forestry.

[25] See also Krewitt 2002., Voß 1999.

Appendix

Table of selected indicators

The following tables provide a synopsis of the selected indicators.

Criteria	Stages of the energy system	Whole Energy System	Indicator	Unit of measurement	Indicators have been developed by drawing on following references:
1.Security/Reliability of Energy Provision					
1.1 Continuity of Energy Service over Time a. System availability on demand b. Diversity of energy suppliers c. Reserves and resources d. Waste management	• Extraction and processing • Transport • Power Plant (conversion to electricity) • Waste management	Energy System	Need of reserve capacity	Load factor	This work
			Market concentration in the supply of primary sources of energy	Ordinal scale	Prognos AG (Hg.) 2000: Energiereport III. Die langfristige Entwicklung der Energiemärkte im Zeichen von Wettbewerb und Umwelt. Schäffer-Poeschel: Stuttgart
			Time span for known reserves and assumed resources for each energy system if used at present rate	Interval scale	Renn, O. 2005: Social indicators for the project 'New Energy Externalities Developments for Sustainability'. Stuttgart
			Probability of the not-in-time availability of a complete waste management concept	Ordinal scale	http://www.environment-agency.gov.uk/subjects/waste/ 1019330/1029396/?lang=_e Internet access: 12.08.2005
1.2. Flexibility and Adaptation a. Flexibility to respond to market signals b. Flexibility to incorporate technological developments	• Extraction and processing • Transport • Power Plant (conversion to electricity) • Waste management	Energy System	System flexibility to react to market changes, in particular sudden fuel price fluctuations	Sensitivity to fuel price fluctuations	Hirschberg et al. 2004: Sustainability of Electricity Supply Technologies under German Conditions: A Comparative Evaluation. Villigen: PSI Report Nr.04-15
			Flexibility to incorporate new technological developments and breakthroughs	Ordinal scale	Häfele, W./Münch, E./Renn, O. (Hg.) 1985: Zukünftige Energiepolitik. Ein Bürgergutachten. Tech: München

Criteria	Stages of the energy system	Whole Energy System	Indicator	Unit of measure-ment	Indicators have been developed by drawing on following references:
2. Political stability and legitimacy a. Potential of conflicts induced by energy sys-tems. b. Willingness to act (mobilization potential) c. Reliance on partici-pative decision-making processes d. Citizens acceptance of the system	• Extraction and proc-essing • Transport • Power Plant (conver-sion to electricity) • Waste management	Energy System	Potential of energy system induced conflicts that may endanger the cohesion of socie-ties	Ordinal scale	Häfele, W./Münch, E./Renn, O. (Hg.) 1985: Zukünftige Energiepolitik. Ein Bürgergutachten. Tech: München
			Willingness of NGOs and other citizen movements to act for or against the realisation of an option	Ordinal scale	Hampel, J./Weimer-Jehle W./Brukmajster D. 2005: Identification and measurement of social indicators for the sustain-ability of selected Swiss electric power systems
			Reliance on participative deci-sion-making processes for different kinds of technologies	Ordinal scale	Nennen, H. U./Hörning, G. 1999: Energie und Ethik. Leitbilder im philosophischen Diskurs. Campus: Frankfurt/N. Y.
			Empirical survey results about citizens acceptance of the power plant	Ordinal scale	Arbeitsgemeinschaft DLR/WI/ZSW/IWR/FORUM 1999: Klimaschutz durch Nutzung erneuerbarer Energien. (Hg.): Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit Bonn

Criteria	Stages of the energy system	Whole Energy System	Indicator	Unit of measurement	Indicators have been developed by drawing on following references:
3. Social and individual risks					
3.1 Subjective risk estimates a. Perceived risk characteristics for accidents b. Perceived risk characteristics for normal operation c. Trust in risk management	• Extraction and processing • Transport • Power Plant (conversion to electricity) • Waste management	Energy System	Psychometric variables such as personal control, catastrophic potential, perceived equity, familiarity and others	Ordinal scale	Lee, R. 1996: externalities studies: why are the numbers different? In: Hohmeyer, O./Ottinger, R.L./ Rennings, K. (Eds.) 1996: social effects and sustainability. Valuation and implementation in the energy and transport sector. Springer: Berlin
			Subjectively expected health consequences from normal operation	Ordinal	This work
			Trust in risk management agencies (private and public)	Ordinal scale	Nennen, H. U./Hörning, G. 1999: Energie und Ethik. Leitbilder im philosophischen Diskurs. Campus: Frankfurt/ N. Y.

3.2 Objective risk estimates (Expert based) a. health effects from normal operation b. Health effects from accidents	• Extraction and processing • Transport • Power Plant (conversion to electricity) • Waste management	Energy System	Mortality due to normal operation (reduced life-expectancy)	YoLL /GWh	Hirschberg et al. 2004: Sustainability of Electricity Supply Technologies under German Conditions: A Comparative Evaluation. Villigen: PSI Bericht Nr.04-15
			Mortality due to severe accidents	Fatalities/GWh	Hirschberg et al. 2004: Sustainability of Electricity Supply Technologies under German Conditions: A Comparative Evaluation. Villigen: PSI Bericht Nr.04-15
3.3 Terrorists threat (only objective side) a. Potential for a attack b. Effects of a successful assault	• Extraction and processing • Transport • Power Plant (conversion to electricity) • Waste management	Energy System	Potential for a successful attack	Ordinal scale	This work
			Maximum potential effects of a successful assault	Maximal number of fatalities	Hirschberg et al. 2004: Sustainability of Electricity Supply Technologies under German Conditions: A Comparative Evaluation. Villigen: PSI Bericht Nr.04-15

Criteria	Stages of the energy system	Whole Energy System	Indicator	Unit of measurement	Indicators have been developed by drawing on following references:
4. Quality of Life					
4.1 Social compatible development a. Equitable life conditions b. Technology specific job opportunities c. Perception of the fairness of risks and benefits	• Extraction and processing • Transport • Power Plant (conversion to electricity) • Waste management	Energy System	Share of the effective electricity costs in a social welfare receiver budget	%	Delfino / Casarin 2001: IEA Statistics: World Energy Statistics Surveys. WPS3599. Internet access: 19.05.2005
			Technology specific job opportunities (direct)	Person-years/GWh	Hirschberg et al. 2004: Sustainability of Electricity Supply Technologies under German Conditions: A Comparative Evaluation. Villigen: PSI Report Nr.04-15
			Perception of the fairness of the distribution of risks and benefits of the energy facility in the neighbouring communities	Ordinal scale	Hampel, J./Weimer-Jehle W./Brukmajster D. 2005: Identification and measurement of social indicators for the sustainability of selected Swiss electric power systems
4.2. Effects on the quality of landscape and residential area 4.2.1 Effects on the quality of the landscape	• Extraction and processing • Transport	Energy System	Land use caused by the energy system	m^2 pro KWh	Maibach, M./Masuhr, K. P. Ott, W. 1996: Die vergessenen Milliarden. Externe Kosten im Energie- u. Verkehrsbereich. Bern: Haupt

a. land use b. Impairment of public area 4.2.2 Effects on the quality of the landscape area a) Aesthetic impairment b) Subjective satisfaction c) Noise exposure d) Contribution to traffic	• Power Plant (con version to electricity) • Waste management		Inaccessible public area because of the energy system	km² pro MWh	Hampel, J./Weimer-Jehle W./Brukmajster D. 2005: Identification and measurement of social indicators for the sustainability of selected Swiss electric power systems
	• Extraction and processing • Transport • Power Plant (conversion to electricity) • Waste management	Energy System	Part of the population that perceives an aesthetic impairment of the landscape area which is caused by the power plant	%	Hampel, J./Weimer-Jehle W./Brukmajster D. 2005: Identification and measurement of social indicators for the sustainability of selected Swiss electric power systems
			Subjective satisfaction of the inhabitants with the power plant	Ordinal scale	Hampel, J./Weimer-Jehle W./Brukmajster D. 2005: Identification and measurement of social indicators for the sustainability of selected Swiss electric power systems
			Number of residents feeling highly affected by noise caused by the energy facility or transports to and from the energy facility	Ordinal scale	Hampel, J./Weimer-Jehle W./Brukmajster D. 2005: Identification and measurement of social indicators for the sustainability of selected Swiss electric power systems
			Contribution to congestion in traffic peak periods through transports to energy facility	Ordinal scale	Hampel, J./Weimer-Jehle W./Brukmajster D. 2005: Identification and measurement of social indicators for the sustainability of selected Swiss electric power systems

Summary of common social indicators

This summary is based on the desktop and literature research that was effected to prepare the development of social indicators for the NEEDS project.

Financial accessibility

- Part of the taxpayers which have a deviance of more than 50% of the average income from all taxpayers
- Number of millionaires (per 100.000 inhabitants)
- Number of homeless people (per 1.000 inhabitants)
- Part of the indebted households accounting to all households (%)
- Percent of population living below the poverty line
- Gini index of income inequality
- Unemployment rate
- Wealth distribution
- Poverty gap index
- Average income

Improved learning abilities

- Education-investigation
- Part of the population with a high education level
- Environmental instruction in schools
- Quality of the environmental education in the population
- Expense for education referring to the gross domestic product
- Number of the patents and licenses per annum

- Part of expenses for investigation and development depending on the whole expenses of private companies
- Part of new innovative products
- World trade parts at investigation-intense products
- Production and diffusion of scientific knowledge
- Number of investigators
- Technological developments and/or transfer

Long-term health effects

- Number of children with allergic reactions
- Individual life expectancy
- Average life expectancy
- Total national health expenditure as a proportion of GDP
- Nutritional status of population
- Social health index
- Human Well-Being Index
- Sanitary effects of illnesses in connection with environmental impacts
- Costs for national health service
- Global distribution of the population
- Human development index
- Communal expenditure for health
- Number of people with cardiovascular diseases
- Number of people with pulmonary diseases
- Number of respiratory diseases by children
- Changes on atmospheric loading
- Number of days with atmospheric ozone

Participation in decision-making processes

- Number of collective decision-making processes in a country
- Costs of collective decision-making processes
- Number of hours that people work honorary for the aims of the Local Agenda 21 (per 1000 inhabitants)
- Number of the visitors at environmental events
- Number of the municipalities which are participating at the concept of Sustainability
- Number of public events within the scope of Sustainability
- Possibility of participation in decision-making processes for all members of the society
- Competence of inhabitants for decision-making processes
- Number of citizens taking part in municipal decision-making processes

Technical accessibility

- Supply guarantee of Energy use
- Technical possibility of Energy supply

Contribution/Integration to local Agenda 21/EMAS

- Environmental friendly actions taken
- Environmental Quality Index:
    - Environmental Pressure Index
    - Ecosystem Risk
    - Ecological Footprint per capita
    - Land use
- Environmental policy issues
- Understanding of global warming

- Centrality of the idea to handle with nature as a resource
- Sum of the environmental investments
- Number of companies with environmental investments
- Number of public activities containing aspects of the Local Agenda 21 and Sustainability
- Information quota for Agenda 21 regarding to the local government
- Number of honorary done jobs regarding to the Agenda 21 per 1000 inhabitants
- Participation of local clubs on the Agenda 21
- Parts of recreation areas which became inaccessible
- Shift of the middle routing distance to recreation areas
- Part of the population that notices a significant aesthetic influence
- Part of the residential area and traffic area regarding to the whole landscape area
- Structure of the use of area

Neighbourhood pollution

- Number of persons which are affected from environmental pollution
- Concerns about air pollutions
- Complaints about environmental pollution
- Environment contentment
- Number of households with new, non-polluting heating systems
- Number of people with significant noise admission in a larger way than n decibel

Long term resources and waste management/entropy measurement

- Probability for a not in time availability of disposal concepts

Risk perception

- Willingness to take over risks
- Perception of own control possibility
- Habituation on risks
- Experience with the power plant
- Perception of the risk potential
- Number of industrial accidents
- Risk appraisal through the community
- Land-use planning controls around risk installations
- Layman estimate from employees and inhabitants: estimated illness and death cases
- Inhabitant appraisals of the risks regarding already existing plants
- Inhabitant appraisals of the risks regarding future plants which are built at the moment
- Risk appraisal through the community
- Hierarchical importance of the security management regarding power plants

Risk management

- Number of people affected by a successful assault
- Existence of a supply loss through a successful assault
- Investment requirement for the restoration of the previous state after a successful assault

- Risk assessment: possible environmental disruption due to accidents, based on historical records and mean expected values as well as on technological risks
- Prevention plans approved and risk-prone municipalities
- Preventive information: progress in implementing the procedure in risk-prone municipalities
- Sufficient authenticity of the power plant operator
- Confidence into the risk management of the plant operator
- Off-site emergency plans and public information
- Technological know-how of the supervision

Compliance with Kyoto targets

- Number of communes with a regular indicator supported documentation of the sustainability
- Part of renewable energies referring to the consumption of electricity
- Expected progress referring to the Kyoto-Protocol
- Number of communes with Agenda-Resolutions
- Number of communes who take regularly report on the state of sustainability

Reliability of energy supply

- Energy intensities: energy supply per unit of GDP and per capita.
- Energy mix: i.e. the structure of energy supply and changes in energy supply.
- Energy prices for industry and households with changes in real energy end-use prices.
- Economic and environmental trends in the energy sector
- Main energy consumers

- Use of the energy
- Final consumption of electricity
- Energy intensity (per capita, per unit of GDP)
- Energy efficiency (energy production/energy consumption)
- Energy efficiency, by relating energy use to GDP (Wh/SKr)
- Amount of electricity used to heat homes and other premises (TW/year)
- Total final consumption of energy
- Total final consumption of energy by type
- Total final consumption of energy by sector
- Number of imported fossil energy resources
- Energy (gas and electricity) consumed by domestic and industrial users per year energy intensities: energy supply per unit of GDP and per capita
- Changes in energy efficiency
- Possibilities of alternative use of primary energy

Access to electricity

- Number of people/households who have access to electricity

Process for conflict resolution

- Conflict difference between layman perception and expert appraisal
- Action willingness for or against the realization of a certain option
- Favouring an option through NGOs
- Existence of conflict implementation concepts

Long term job opportunities

- Number of people moving into a region and moving away from that region

Good job

- Direct and indirect jobs created in the sector of renewable energies
- Net employment generation: number of jobs/tons of avoided GHG emissions in Co2 equivalent
- Number of qualified working places
- Number of working places which are affected from emissions
- Number of working places which are affected from potential technical breakdowns

Regional economic development

- Attractiveness of the area for employees
- Attractiveness of the area for visitors
- Expansion of the plot prices
- Influence of the site quality according to appraisals of economic experts

Distribution of positive/negative outcomes

- Distribution of the emissions between site and use place
- Potentially endangered groups of persons which are involved in the plant production
- Inhabitants' subjective perception of the fairness, regarding to the risk-chance-distribution of the power plant

Perceived acceptance

- Power plants acceptance of inhabitants and actors, which are affected by power plants. Actors: inhabitants, energy producer, power plant producer, public bodies
- Acceptance of used energy technique
- Acceptance of renewable energies in the population and affected stakeholders, like energy producer
- Subjective contentment of the employees referring to the acceptance of the power plant

Proportion of energy cost in the family budget

- Part of the effective electricity costs regarding a social welfare receiver's budget
- Part of the effective electricity costs regarding an average household budget
- Transport infrastructure
- Contribution to the traffic utilization at peak times
- Part of the Energy amount regarding to traffic
- Per capita consumption of fossil fuel by motor vehicle transport
- Energy consumption by the transport sector

Political risks

- Options for reforms regarding economic sustainability

Life cycle of technologies/full marginal costs

- Probability of the early closure

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