KTH Architecture and
the Built Environment

Towards a user's guide to scenarios - a report on scenario types and scenario techniques

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Version 1.1b, November 2005

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ISSN 1652-5442
TRITA-INFRA-FMS 2005:3, version 1.1b November 2005

Printed in Sweden by US AB, Stockholm, 2005

Preface

This report has been developed within the project MEMIV (Common Techniques for Environmental Systems Analysis Tools) funded by MISTRA (the Foundation for Environmental Strategic Research). Previous versions of the report have been discussed during several meetings within the research team, seminars and lectures and with Anders Eriksson, FOI. The authors are grateful to all those who have contributed. A shorter version of the report will be published in Futures during 2006.

Summary

Futures studies consist of a vast variation of studies and approaches. The aim of this paper is to contribute to the understanding of for what purposes scenarios are useful and what methods and procedures are useful for furthering these purposes. We present a scenario typology with an aim to better suit the context in which the scenarios are used. The scenario typology is combined with a new way of looking at scenario techniques, i.e. practical methods and procedures for scenario development. Finally, we look at the usefulness of scenarios in the light of the scenario typology and the scenario techniques.

As a start, we distinguish between three main categories of scenario studies. The classification is based on the principal questions we believe a user may want to pose about the future. The resolution is then increased by letting each category contain two different scenario types. These are distinguished by different angles of approach of the questions defining the categories. The first question, *What will happen?,* is responded to by **Predictive scenarios.** In fact, the response to a question like this will always be conditional, e.g. of a stable and peaceful world, or by a certain continuous development of some kind. We have utilized this fact when defining the two predictive scenario types, Forecasts and What-if scenarios. The second question, *What can happen?,* is responded to by **Explorative scenarios.** The scenarios are thus explorations of what might happen in the future, regardless of beliefs of what is likely to happen or opinions of what is desirable. This category is further divided into external and strategic scenarios. The final question, *How can a specific target be reached?,* is responded to by **Normative scenarios**. Such studies are explicitly normative, since they take a target as a starting point. They are often directed

towards how the target could be reached. This category is divided into preserving and transforming scenarios.

If the user wants to predict the future, forecasts and what-if scenarios are of interest. If the user wants to think in terms of several possible futures, perhaps in order to be able to adapt to several different types of outcomes, explorative scenarios may be useful. If the user wants to search for scenarios fulfilling specific targets, and maybe link this to actions that can be taken towards the visions, normative scenarios should be the choice. Those three approaches to scenario studies are different. By emphasising the user's perspective to scenario studies, we have argued that the choice of scenario category is not only a question of the character of the studied system. Instead, the user's worldview, perceptions and aim with the study can be even more important for the choice of approach.

1. Introduction

Futures studies consist of a vast array of studies and approaches and the area has been called a 'very fuzzy multi-field' (Marien 2002) and among futurists themselves there is no consensus on how to categorise and delineate futures studies. According to Amara (1981) the futures field concerns the exploration of possible, probable and preferable futures (Amara 1981). Marien (2002) states that most futurists should describe their activity as exploring probable, possible and preferable futures and/or identifying present trends. Besides these, Marien adds the categories "panoramic view" and "questioning all the others". The study of the future is conducted at a wide range of instances in society such as universities, special research institutes and as integrated part of the work of authorities and companies. The field is multidisciplinary and concerns areas such as economy, technology and societal planning. There are various reasons to study the future, e.g. a perceived need to foresee and adapt to coming events or to explore how it is possible to influence the evolution.

Futures studies in the western tradition have ancient roots and through history there are numerous examples of various utopias and prophecies (Cornish 1977, pp. 51-57). Predictions have also been made within the natural system with increasing accuracy during a long period of time. The Ptolemaic system of astronomy which was developed almost 2000 years ago, could predict the movement of any star with an astonishing accuracy for that time (Makridakis et al. 1998, p. 2). Forecasting methods were also developed and utilized for making predictions in other areas, for example economy; in the middle of 1930s, economists had begun using economic forecasting for testing their models (Clements and Henry 1998, p. 7).

Modern futures studies primarily evolved after World War II. Two different kinds of futurology were developed in Europe and United States. The

European tradition contained democratic elements and an ambition to radically change society. In United States a tradition of technological forecasting that could be of interest to the military was initiated in the 1940s, and Project RAND (Research ANd Development) was established in 1946 to study the intercontinental non-surface warfare. Two years later, Project RAND became the RAND Corporation and the focus switched from merely studying alternative weapon systems to exploring national policies (Cornish 1977, pp. 78-91).

During the 1950s and 1960s there was a steady economic growth in the industrialized world and forecasting methods was rather successfully used to predict the future. In the 1970s unforeseen events such as the oil-crises and an increasing rate of change of the society (Godet 1979) radically altered the conditions for studying the future. The forecasting methods often turned out to be of little use. In this climate, a method of exploring different possible futures was developed within Shell inspired by the RAND Corporation, Herman Kahn and the Hudson Institute (van der Heijden 1996, pp. 15-18).

The normative planning approach backcasting emerged in the early 1970s as a response to a demand for a futures study approach that could cope with situations where an actor wanted to investigate how certain targets could be fulfilled even though forecasts indicated that those targets would not be met. Backcasting was first used in the area of planning of electricity and energy supply.

Within the field of futures studies a number of concepts are quite contested. One of the most basic, although contested, concepts in this field is 'scenario'. It can denote both descriptions of possible future states and descriptions of developments. In some contexts, the term is used mainly for the exploration of a broad field of possible futures, in contrast to e.g. predictive modelling with a more limited variations analysis (van der Heijden 1996; Dreborg 2004; Eriksson 2004). Aligica (2004) notes that Kahn (Kahn and Wiener 1967, p. 6) distinguish scenarios from alternative futures. Scenarios denoted "hypothetical sequences of events constructed for the purpose of focusing attention on causal processes and decision points", whereas "alternative futures" emphasize the final state. However, Aligica notes, nowadays both alternatives would usually be included under the heading of "Scenario building". Along the same line, we have chosen to use a broad scenario concept that also covers predictive approaches with sensitivity testing, despite the fact that early scenario developers such as Kahn and Wiener (1967, p. 6) would reject such a use of the term. The reason for our choice is that many practitioners use the term in this sense.

Various typologies have been suggested in attempts to make the field of futures studies easier to overview. Typologies can be important tools for communicating, understanding, comparing and developing methods for futures studies. Without a common language among researchers, all those tasks become much harder. However, it can be useful to have more than one typology, since different typologies can have different objectives.

The aim of this paper is to contribute to the understanding of for what purposes scenarios are useful and what methods and procedures are useful for furthering these purposes. We present a scenario typology based on previously presented typologies, but adjusted with an aim to better suit the context in which the scenarios are used. The scenario typology is combined with a new way of looking at scenario techniques, i.e. practical methods and procedures for scenario development. Finally, we look at the usefulness of scenarios in the light of the scenario typology and the scenario techniques.

We take a users' perspective when discussing the different scenario types and scenario techniques. Users, in our terminology, can be of quite different kinds. They can be those who generate scenarios, those who use already existing scenarios and those to whom scenarios are directed, even though they may not have asked for it. This calls for an approach in which purpose and characterising qualities of different types of scenarios are highlighted. The paper is intended as a first step towards a guide to how scenarios can be developed and used. This kind of guide would be useful for any researcher, planner or investigator who is about to begin a structured future-oriented study, but has a limited previous knowledge of futures studies approaches. A guide of this kind could also be of interest as an aid when evaluating the usefulness of a specific scenario study for a specific problem. We also believe that such a guide could be useful for users with a rather long experience from scenario work, in that it may force this user to clarify the purpose of the scenarios.

In the next section, we look at a couple of previously presented scenario typologies. In section 3, we present the typology we propose, as a basis for discussing the matching of scenario types with user needs. Section 4 includes a description of various techniques for studying the future. The aspiration has been to select techniques that are in use and conceived as important, and to highlight reasons for a user to choose one or the other. In Section 5, we discuss the applicability of different techniques in the different scenario types. We conclude the paper with a discussion regarding the chosen vantage point of the presented typologies.

2. Previously presented typologies

Over the years, a large number of typologies over futures studies have been developed. Some of them are rather similar, whereas there are a few with a completely special angle. As an introduction to futures studies typologies we here present a selection of typologies, mainly picked from past volumes of Futures. Six of the typologies are collected in a paper by Tapio and Hietanen (2002). Our presentations are very short, but can still give an idea of the range of typologies in the literature.

van Notten et al (2003) elaborate a typology for scenarios where scenarios are divided in overarching themes. These are the project goal (why?), process design (how?) and scenario content (what?). The project goal can be explorative or decision support. The process design can be intuitive or formal and the scenario content complex or simple. The overarching themes are then further divided into more detailed characteristics. The aim with the paper by van Notten et al is mainly to produce a better picture of the field of futures studies, to be used for further developments of scenario methodology. Thus, it is more descriptive than prescriptive

Dreborg (2004, p. 19) identifies three classical modes of thinking in futures research. These are the predictive mode of thinking, the eventualities mode of thinking and the visionary mode of thinking. To each of the modes of thinking, Dreborg assigns methodologies to study the future. These are most often dominated by one of the modes of thinking, but there are also mixes. Forecasting, external scenarios and backcasting are examples of methodologies that are quite 'pure' forms of the modes of thinking about the future. Forecasting in a narrow sense then belongs to the predictive mode of thinking, external scenarios to thinking in eventualities, and backcasting to thinking in visions (Dreborg 2004, p. 19-20).

Amara (1981) distinguishes three goals that futurists attempt to achieve. The goals have to do with the "Probable, possible and preferable". Another typology (Sandberg 1976; Mannermaa 1986; Slaughter 1988), built on Habermas, divides futures studies in "Technical, hermeneutic/practical and emancipatory interests of knowledge". In the technical, focus is on objective trends. Hermeneutic aims at increasing a common understanding of social reality, whereas emancipatory interest of knowledge aims at widening the perceived scope of options.

Masini (1993, pp. 45-46) finds three approaches in futures studies: "Extrapolation, utopian and vision. The utopian approach includes both positive and negative futures and is characterised by the difference to the probable. The visionary approach has to do with how the utopias could come about.

Inayatullah (1990) identifies three perspectives to futures studies – "Predictive-empirical, cultural-interpretative and critical-post-structuralist". The cultural-interpretative perspective includes an emphasis on understanding, negotiating and acting in order to achieve a desired future. In the Faucault-inspired critical perspective, the focus is on analysing historical context and power relations and on emphasising the difficulties in statements regarding future developments.

Bell (1997) formed three epistemologies - Positivism, critical realism and post-positivism. The first is similar to Amara's "probable" and the third shows similarities to Inayatullah's critical post-structural approach. The second represents an approach where the aim is to find the objectively good. Focus is on the evaluation of various possible futures according to objective facts.

The final typology that Tapio and Hietanen reports upon is Mannerma's "Descriptive, scenario paradigm and evolutionary" (Mannermaa 1991). The descriptive means the same as the technical interest of knowledge mentioned above (Sandberg 1976; Mannermaa 1986; Slaughter 1988). In the scenario paradigm the main purpose does not lay in predicting, but to construct several different futures and paths to them. No single scenario method is recommended as the preferred method. The last of those three adopts a world-view of society developing in phases with good predictability combined with phases of chaotic bifurcations. The challenge is here to make future assessments in the bifurcations and to forecast in linear phases.

Tapio and Hietanen themselves develop their own typology with six futures studies paradigms, based on different roles of actors in long-term planning and decision making processes. It can for example be used for analysing if an actor is involved in policy processes implying philosophical positions contradicting the actor's own basic assumptions, or as a tool for analysis of which school of thought is represented in empirical policy processes. The six paradigms defined by Tapio and Hietanen are Comtean positivism, Optimistic humanism, Pluralistic humanism, Polling democracy, Critical pragmatism, Relativistic pragmatism and Democratic anarchism. The paradigms are defined by the view on knowledge and values, with a gliding scale from the Comtean positivist belief in objectivity to the Democratic anarchists rejections of any policy recommendations, due to the belief that all knowledge is biased and all values too subjective.

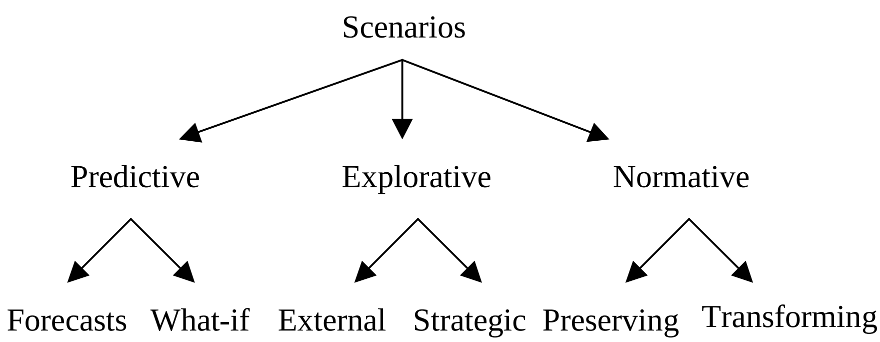
The different typologies above all have their merits. Obviously, it can be useful to have more than one typology of futures studies, since different typologies have different objectives. This paper presents a typology that resembles that presented by Amara (1981). Like Dreborg (2004, p. 19-20), we discuss methods that are suitable for developing different scenario types. However, our aim is to describe the methods and procedures on a more operational level, and our starting point is the purpose of the futures studies. The paper is intended as a first step towards a guide to how scenarios can be developed and used. Scenario users, in our terminology, can be those who generate scenarios, those who use already existing scenarios and those to whom scenarios are directed, even though they may not have asked for them. The paper also includes a discussion on different types of scenario techniques and examples are used to illustrate the typology.

3. A scenario typology

Several of the nine typologies presented above build on variants of the categories probable, possible and preferable. We essentially join this tradition because we believe these categories reflect three basically different modes of thinking about the future (Dreborg 2004). However, we adjust the typology in order to emphasise our basis in how the scenarios are used.

We distinguish between three main categories of scenario studies. The classification is based on the principal questions we believe a user may want to pose about the future. These are *What will happen?*, *What can happen?* and *How can a specific target be reached?*. The resolution is then increased by letting each category contain two different scenario types, see Figure 1. These are distinguished by different angles of approach to the questions defining the categories.

Figure 1. Scenario typology with three categories and six types.



In addition to the principal questions above, there are two more aspects of the system under study that we consider to be particularly important when characterising scenarios. The first of these is the concept of *system structure*, by which we mean the connections and relationships between the different parts of the system, and also the boundary conditions, which govern a system's development. When it is possible to build a mathematical model of a system under study, the equations are an interpretation of the system's structure (it could e.g. be linear or non-linear). The second important aspect of the system is the distinction between internal and external factors. By internal factors we mean factors that are controllable by the actor in question, while external factors are outside the scope of influence of the actor.

The first of the questions above, *What will happen?,* is responded to by **Predictive scenarios.** Predictive scenarios consist of two different types, distinguished by the conditions they place on what will happen. *Forecasts* respond to the question: What will happen, on the condition that the likely development unfolds? *What-if scenarios* respond to the question: What will happen, on the condition of some specified events?

The aim of predictive scenarios is to make an attempt to predict what is going to happen in the future. The concepts of probability and likelihood are closely related to predictive scenarios since trying to foresee what will happen in the future in one way or another has to relate to the (subjectively) estimated likelihood of the outcome.

Predictive scenarios are primarily drawn up to make it possible to plan and adapt to situations that are expected to occur. They are useful to planners and investors, who need to deal with foreseeable challenges and take advantage of foreseeable opportunities. Predictions can also be used to make decision-makers aware of problems that are likely to arise if some condition on the development is fulfilled.

Predictions are usually made within one structure of the predicted system, i.e. it is assumed that the laws governing a system's development will prevail during the relevant time period. Historical data many times play an important role when outlining the scenarios. The focus is on causalities, which in a step-wise manner lead to an outcome.

Predictions can also be self-fulfilling. Predicted traffic growth may, for instance, lead to the building of more roads, which stimulates an increase in traffic. The self-fulfilling aspect of predictions makes it possible to use them also for long-term planning and investments in infrastructure. However, the fact that predictions can contribute to preserving past and present trends can also make it more difficult to change undesirable trends.

Forecasts are conditioned by what will happen if the most likely development unfolds, i.e. when making a forecast the basic supposition is that the resulting scenario is the most likely development. Forecasts give one reference result which may be accompanied by results of the type 'high' and 'low ', indicating a span. Forecasts can be used as an aid for planning in, for example, the business environment (Makridakis et al 1998, p. 3). In such cases forecasts are made of external factors. These can be economic events, natural phenomena and organisational statistics. Those forecasts are most suited to the short-term, when the uncertainty in the development of the external factors is not too great.

What-if scenarios investigate what will happen on the condition of some specified near-future events of great importance for future development. The specified events can be external events, internal decisions or both external events and internal decisions. What-if scenarios can be said to consist of a group of forecasts, where the difference between the forecasts is more than a matter of degree regarding a single exogenous variable. The differences are more like a 'bifurcation'[1] where the event is the bifurcation point. The difference is fundamental and obvious, e.g. 'yes' or 'no' in an important referendum. None of the scenarios is necessarily considered as the most likely development. The resulting what-if scenarios hence reflect what will happen, provided one of two or more events happens. A similar case is when sets of decisions or outcomes are collected in packages, or policy packages. The bifurcation point is less significant in such cases, but if the differences between the packages are of vital importance for the further development of the system studied, it is still a case of what-if-scenarios. So-called probabilistic scenarios, in which probabilities of some important outcomes are estimated and then followed by a forecast for each outcome, can be seen as yet another special kind of what-if scenario.

In World Energy Outlook 2002 (OECD/IEA 2002, p. 502), adjustments to parameters of the energy model are sometimes made to take into account expected structural changes in the not so distant future. The purpose of the projections is to analyse the possible evolution of energy markets (OECD/IEA 2002). Two assumption sets are used as input to the model; a scenario called Reference Scenario and one called OECD Alternative Policy Scenario. The assumptions of the scenarios are generally based on historical values and trends. The difference between the two is that the OECD Alternative Policy Scenario includes new policies on environmental issues and the Reference Scenario only existing ones (OECD/IEA 2002, pp.38-55). Hence, in our terminology, the World Energy Outlook 2002 is an example of predictive what-if scenarios of the 'package-kind'.

An advantage with defining what-if scenarios as a group of their own, and not letting them be part of the forecasting type in the typology, is that the

[1] The “bifurcation” in what-if scenarios can however split development into more than two paths.

outcome is of a different character than the outcome from an ordinary forecast. From a user's perspective, it is a completely different thing to handle a forecast with a sensitivity span and to handle a result consisting of distinctly different outcomes.

The **explorative scenarios** are defined by the fact that they respond to the question *What can happen?* We distinguish between the two types, external scenarios and strategic scenarios. External scenarios respond to the user's question: What can happen to the development of external factors? Strategic scenarios respond to the question: What can happen if we act in a certain way?

The aim with explorative scenarios is to explore situations or developments that are regarded as possible to happen, usually from a variety of perspectives. Typically a *set* of scenarios is worked out in order to span a wide scope of possible developments. In this, explorative scenarios resemble what-if scenarios, but the explorative scenarios are elaborated with a long time-horizon to explicitly allow for structural, and hence more profound, changes. Furthermore, the explorative scenarios more often take their starting point in the future, compared to what-if scenarios, which are usually developed from the present situation. However, long-term predictions, denoted surprise-free scenarios, are often used as reference scenarios in such studies.

Explorative scenarios can help explore developments that the intended target group in one way or another may have to take into consideration. This can be in situations when the structure to build scenarios around is unknown, e.g. in times of rapid and irregular changes or when the mechanisms that will lead to some kind of threatening future scenario are not fully known. Explorative scenarios can also be useful in cases when the user may have fairly good knowledge regarding how the system works at present, but is interested in exploring the consequences of alternative developments. Explorative scenarios are mainly useful in the case of strategic issues (van der Heijden 1996, p. 86).

External scenarios focus only on factors beyond the control of the relevant actors. They are typically used to inform strategy development of a planning entity. Policies are not part of the scenarios but the scenarios provide a framework for the development and assessment of policies and strategies. The external scenarios can then help the user to develop robust strategies, i.e. strategies that will survive several kinds of external development.

External scenarios can be produced with a rather broad target group, since the scenarios generated are often rather general, e.g. global energy or climate scenarios. When it comes to certain types of climate modelling, for example, the outcome depends on assumptions regarding how the atmosphere and the sea absorb climate gases. Completely different developments are possible depending on how those ecosystems react. The result then forms a basis for discussions on different measures.

External scenarios can also be produced within a specific company or organisation. Some advantages with external scenarios are that they open up the possibility to find flexible and adaptive solutions for an actor whose influence on external factors is small. One specific way of doing this is through the use of scenario planning, a methodology initially aimed at creating business strategies that are robust across a range of different possible future developments (Wack 1985; van der Heijden 1996). External scenarios may also make the organisation more receptive to weak signals of radical changes in the actor's environment. Furthermore, external scenarios, as in the process of scenario planning, have demonstrated an ability to contribute to the creation of a common understanding in organisations and when people from different backgrounds and with different goals meet (van der Heijden 1996, p. 86).

Strategic scenarios incorporate policy measures at the hand of the intended scenario user to cope with the issue at stake. The aim of strategic scenarios is to describe a range of possible consequences of strategic decisions. Strategic scenarios focus on internal factors (i.e. factors it is possible to affect), and take external aspects into account. They describe how the consequences of a decision can vary depending on which future development unfolds. In these scenarios the goals are not absolute but target variables are defined. Different policies are typically tested and their impact on the target variables is studied. The strategic scenarios are not only relevant to decision makers; they are also useful as inspiration for interested parties, such as policy analysts or research groups.

The final question, *How can a specific target be reached?,* is responded to by **Normative scenarios**. Normative scenarios consist of two different types, distinguished by how the system structure is treated. *Preserving scenarios* respond to the question: How can the target be reached, by adjustments to current situation? *Transforming scenarios* respond to the question: How can the target be reached, when the prevailing structure blocks necessary changes?

In the case of normative scenarios, the study has explicitly normative starting points, and the focus of interest is on certain future situations or objectives and how these could be realised. When it seems possible to reach the target within a prevailing structure of the system, the preserving scenario approach would be appropriate. On the other hand, if a transformation into a structurally different system is supposed to be necessary in order for the goal to be attained, transforming scenarios can be useful. In the transforming scenario approach, the idea of modelling the structure of the system is often rejected. Trends are thought to go in the wrong direction and the current structure to be part of the problem.

In normative *preserving scenarios*, the task is to find out how a certain target can be efficiently met, with efficiently usually meaning cost-efficiently. This can be done either with some kind of optimising modelling, such as using the optimising energy model MARKAL (Fishbone and Abilock 1981), or in a more qualitative way. One example when this is done in a qualitative way is in regional planning, where the starting point for a new plan is often a group of targets concerning environmental, social, economic and cultural factors. Planners or experts then make judgements on which is the most efficient path to reach specific target or several targets. This path could be seen as a preserving normative scenario. Such scenarios are not optimising in a mathematical sense, but merely 'satisfying'.

In *transforming scenario* studies, such as backcasting, the starting point is a high-level and highly prioritised target, but this target seems to be unreachable if the ongoing development continues (Höjer 2000, p. 13). A marginal adjustment of current development is not sufficient, and a trend break is necessary to reach the target. The result of a backcasting study is typically a number of target-fulfilling images of the future, which present a solution to a societal problem, together with a discussion of what changes would be needed in order to reach the images. It has a rather long time-perspective of 25-50 years (Robinson 1990). Dreborg (1996) stresses the importance of elaborate images of the future as a foundation for discussing goals and taking decisions in policy-forming processes. Höjer and Mattson (2000) believe that the point of backcasting is to encourage searches for new paths along which development can take place.

Höjer (2000, p. 14-15) claims that a distinction between external and internal factors is not important in a backcasting study. Keeping all the factors internal to the backcast itself can in fact help to display factors that may be crucial for reaching the targets, which is one idea of the backcasting study. Hence all solutions are kept open and no restrictions are imposed by initially defining some factors as external.

From a user's perspective, an important difference between backcasting and optimising scenarios is that optimising scenarios serve to find efficient solutions, whereas backcasting scenarios focus on finding options that satisfy long-term targets. A problem with the backcasting approach is that it can result in decisions that are expensive in the short term and that the long-term target, or available options, can change before the target year is reached. Optimising has the potential drawback that the life-cycle of an investment may be much longer than the time period for which the key aspects for investment decisions (such as technology and fuel prices) are predictable and that near-term investment decisions can counteract the fulfilment of long-term targets. Therefore, it can be reasonable to choose backcasting and not optimising scenarios when the long-term target is perceived as more important than short-term efficiency and/or when the user perceives the long-term target to be easier to predict than fuel prices, etc. If the converse is the case, optimising scenarios are preferable to backcasting.

We conclude this section by using two IPCC reports as illustrative examples. In order to span a wide range of various possible changes, four qualitative world scenarios are described in *Emissions Scenarios* (IPCC 2000). They exhibit partly different drivers of the development and, therefore, must be classified as structurally different. These are thus of an explorative character. The report then focuses on the subsystems that generate emissions of greenhouse gases. Here, several research teams with different emissions models analysed emissions in the respective world scenarios. The models represent partly different interpretations of the systems' structures. The reason for this approach is that there is a structural uncertainty as regards the mechanisms that generate emissions. The resulting emissions scenarios, thus, were structurally different.

Based on the qualitative world scenarios, each group made its quantifications of relevant exogenous variables to be fed into the models. Hence, the resulting emissions scenarios of the different teams normally differed both as a result of different interpretations of exogenous variable values and different interpretations of system structure. In order to make possible a separation of these effects, all teams were instructed to use a common set of exogenous variable values as a reference case, in addition to runs based on their own interpretations of input data. In this way, the report entails explorative scenarios in order to cope with structural uncertainty, as well as a sensitivity analysis in order to cope with uncertainties related to input data. It seems reasonable to say that the approach of IPCC (2000) combines the methodologies of What-if scenarios and explorative external scenarios.

The emissions scenarios do not entail any specific emissions reducing policies. In the report *Mitigations Scenarios* (IPCC 2001), such policies are added to the emissions scenarios with the aim of attaining stabilisation of CO_2-concentration in the atmosphere at targeted levels. The clearly stated aim of stabilising CO_2-concentration makes these scenarios normative. Some of the scenario building groups utilised optimisation models, optimising the set of technology and policy measures based on the constraint on CO_2 emission concentrations. Two modelling teams used recursive simulation-type models, while other teams used other types of integrated models. Hence, all groups used a modelling approach but just one-third used an optimisation model. One of the major results of the mitigation study was the identification of robust climate policy options across the different qualitative and quantitative scenarios (IPCC 2001) and in our terminology those were of the preserving scenario type.

According to Marien (2002), most futures studies belong to just one of the categories probable, possible and preferable, which roughly correspond to the triad predictive, explorative and normative used in this paper. However, according to Robinson (2003), there is a tendency for studies to use more complex methodologies. The IPCC case is a good illustration of a mixed highly complex methodology covering predictive, explorative and normative elements and also qualitative and quantitative approaches.

4. Techniques

The process of scenario development includes various parts or elements, i.e. there are a number of identifiable tasks to handle in scenario studies. First, there is an element consisting of the **generation of ideas** and gathering of data. Second, there is an element of **integration** where parts are combined into wholes. Third, there is an element of **checking the consistency** of scenarios.

Below we discuss different techniques under the headings of *generating, integrating* and *consistency*. Several techniques exist that address one or several of the elements. These will be entered under the most suitable of those. The aspiration was to select techniques that are being used and that are regarded as important. A description of the techniques is made to enable a discussion on the linking of techniques and scenario types in the next section. The difference between the three kinds of techniques is presented in Box 1.

Box 1. The three kinds of scenario techniques presented in this paper, distinguished by their main contribution to scenario building.

Generating techniques: The main focus lies in generation of ideas and collection of data.

Integrating techniques: The main focus is in combining parts into wholes.

Consistency techniques: The main focus lies in checking the consistency of outline scenarios.

4.1 Generating techniques

Generating techniques are techniques for collecting ideas, knowledge and views from e.g. experts or stakeholders. Examples of such techniques are surveys, Delphi-methods and workshops. Interviews can be elements in all of these techniques.

Survey research is a technique to systematically collect people's opinions regarding a general or specified issue. It is possible to study the opinion of large collectives or those of any subpopulation. The surveys could be performed with interviews face to face, by telephone, or a written questionnaire (Bell 1997, p. 257). In scenario studies surveys are usually used to ask about peoples intentions or how they expect something particular to develop. As an example Sahlin et al. (2004) distributed a questionnaire to all relevant Swedish producers of district heating asking how the expected expansion of district-heating based on waste affected their plans for future investments and utilisation of other heat sources. Other examples include surveys asking consumers about their intentions to buy a particular product (Bell 1997, p. 258).

The Delphi method was developed by the RAND Corporation in the late 1950s. Nowadays there are various variants of the method. The main idea of a classical Delphi study is to collect and harmonize the opinions of a panel of experts on the issue at stake. It recognizes the human judgement as a legitimate input to forecasts and also that the judgement of a number of informed people is likely to be better than the judgement of a single individual, who may be misinformed or highly biased (Cornish 1977, p. 118-119). In the original Delphi method the procedure is lead by a coordinator who formulates questions, typically regarding e.g. technological breakthroughs, that are sent to a panel of experts of the issue at stake in various rounds. The result is a consensus forecast or judgement (Cornish 1977, p. 119). The technique has been used to produce forecasts in the form of a list of potential future occurrences, likely dates of their occurrences and their probability (Gordon and Hayward 1968). A lot of criticism has been raised against the Delphi method. Some critics argue that striving for consensus results in losses of important information (Asplund 1979).

A modified Delphi method was elaborated by Best et al. (1986). In this modified version, different groups of opinions are identified after the first round of questionnaire. Within these groups, a procedure similar to a conventional Delphi method is performed with a view to produce meaningfully different but cohesive alternative futures. The point is that the study results in different possible futures, still being subjugated to the Delphi process. The study concerns factors in the future environment that could have an impact on the analysed system.

A Backcasting Delphi method, which is a combination of a backcasting and Delphi study was developed by Höjer (1998). The Backcasting Delphi method starts with the first part of a backcasting study, i.e. formulating scenarios of a future that is desirable in some sense. The second part, examining the path to the images of the future, is left out of the study. Instead a Delphi-like process is initiated where experts are asked to evaluate and improve the scenarios in respect of their feasibility and coherence to the defined targets.

Workshops are frequently used in scenario development contexts, especially scenarios of a more qualitative character. A workshop is a kind of idea seminar where a smaller or larger group of people, e.g. from a company or citizens, come together in order to elicit and structure ideas. Usually, when holding a workshop, some kind of elaborate method is used. One example is the scenario planning process described by van der Heijden (1996). The scenarios in scenario planning are elaborated in workshops with participation of the stakeholders. In a process of identification of events, clustering them and searching for causalities, driving forces are identified by revealing the underlying structure of events.

Surveys, Delphi-methods and workshops are various kinds of techniques where panels are used. Thus panels can be used in many different ways. For example, all people involved do not necessarily meet and, the panel process might proceed for a shorter period of time (a day or less) or take much longer time (years). The generating techniques described above are listed in Box 2.

Scenarios are sometimes elaborated as internal scenario project work. In this kind of scenario studies one researcher, a group of researchers or a scenario project team produce the scenarios back-office. We refer the think-tank model, primarily pioneered by the RAND Corporation (Cornish 1977, p. 85), to this kind of technique. The think-tank model is a label for a multidisciplinary research team addressing a certain problem.

Box 2. The generating techniques that are highlighted in this work. The generating techniques are primarily used for generation of ideas and gathering of data.

Examples of generating techniques:		
Survey research	Delphi-methods	Workshops

4.2 Integrating techniques

Modelling is a prominent group of techniques for combining parts into wholes. A model structure also facilitates a systematic collection of data, which helps ensuring that the different parts of the system are consistently described. These kinds of techniques are frequently based on mathematical modelling. Three subgroups of such mathematical models can be distinguished. These are time-series analysis, explanatory modelling and optimising modelling. The focus in those techniques is on projecting some kind of development with more or less explicit constraints. Assumptions can be simple, such as a simple extrapolation of a variable, or more complex, such as assuming causal relationships between variables.

Time series analysis is a quantitative technique to make forecasts by extrapolating one variable into the future based on historical values of the same variable. In time-series analysis the system in question is treated as a black box. The underlying causes of the development are not in focus, either because they are expected to be too difficult to find, or because the results are given higher priority than the behaviour of the system (Makridakis, Wheelwright et al. 1998, p.11). Usually, the analyst looks for patterns as trends and cycles that can be projected. Time series extrapolation is for example used to predict the size of human populations (Bell 1997, p. 255). Time series analysis works best when correct quantitative data have been recorded for a reasonably long period of time (Bell 1997, p. 255).

In explanatory modelling inter-relationships between variables are taken into account by projecting not variables but relationships into the future. The term explanatory model is used to describe one type of forecasting models by Makridakis et al. (1998, p. 10), but we do not confine the term to represent forecasts. Simulation, in the meaning of representing one part of reality in a model as an aid to figure out what would happen in this part of reality under various conditions, is included in the concept of explanatory modelling.

Optimising models also projects relationships into the future but are distinguished from explanatory modelling by explicitly having an optimising aim. There exists a vast amount of different mathematical optimization techniques aiming at maximizing or minimizing some kind of utility or cost, see e.g. (Miller 2000). Some examples of optimising models are the energy sector linear program models MARKAL (MARKket ALlocation) (Fishbone and Abilock 1981), or EFOM (Finon 1979). The widely used MARKAL is a model of the technical energy system which was primarily developed for national energy systems. MARKAL minimizes an objective function, e.g. discounted cost, subject to specified constraints. It demands forecasts and/or some kind of assumptions of external variables as input to the model (Fishbone and Abilock 1981). The output of MARKAL and similar models is a selection of the most cost-efficient mix of technologies and fuels to meet the various exogenously-determined energy demands, complying with determined constraints, if the minimization of discounted cost over the entire planning horizon is chosen as the objective function (Zhang and Folmer 1998). Other examples of optimising models are the hard-linked energy economy model MARKAL-MACRO (Nyström and Wene 1999), computable general equilibrium (CGE-) models, described by e.g. Ahlroth et al. (2003, p. 23-29) and partial equilibrium models, (Ahlroth et al. 2003, p. 24-28). Descriptions of different optimising models can be found in (Unger 2003), (Zhang and Folmer 1998), (Ahlroth et al. 2003) and (Larsson 1997).[2]

The integrating techniques described above are listed in Box 3.

Box 3. The integrating techniques that are highlighted in this work. The primarily benefit of the integrating techniques lies in their ability to form parts into wholes.

Examples of integrating techniques:		
Time-series analysis	Explanatory modelling	Optimising modelling

[2] Optimising models are also generating in that they generates solutions and policy proposals for specific problems. This is in fact an important difference between optimising and simulating modelling.

4.3 Consistency techniques

The third group of techniques we would like to highlight here are formalised consistency techniques. Although some of these are also used for idea generation and/or integration, their usefulness for securing the consistency between or within scenarios, could be seen as their main advantage. Cross-Impact Analysis and Morphological Field Analysis, two formalised qualitative methods, can be seen as examples of such techniques.

Cross-impact analysis was developed to take account of interactions among events and developments as a response to some of the shortcomings of the original Delphi method and other forecasting techniques, where forecasts are produced in isolation from each other (Gordon and Hayward 1968). According to a description in Smith (Smith 1987), a matrix is constructed to show and analyse interdependencies between events. The matrix lists a number of events that may occur along the rows and the columns of the matrix. Usually the events are the same in the rows and in the columns. Respondents are then asked to give their opinion of the probability of occurrence of a column element given that a row element has occurred. This probability is then filled in the matrix. The cell-entries thus represent the factor by which the probability of the occurrence of a column event would increase or decrease conditioned by the occurrence of the row element. Given the matrix, plus the initial probabilities of occurrence, there is the possibility of a large number of simulated futures as the occurrence of one event re-conditions the probabilities of all other events (Smith 1987, p. 50). The consistency of different forecasts is in the cross-impact analysis tested as regards causality. The cross-impact analysis is in some sense also generating since it generates sets of forecasts that are consistent with respect to causality, see e.g. (Gordon and Hayward 1968). Within a cross-impact analysis there are e.g. conceived methodologies to "play out" the matrix, thus for example enabling revision of the initial judgments of probabilities, see e.g. (Gordon and Hayward 1968) or (Martino 1972, pp.272-279). Another application of the cross-impact analysis is to test policies. The probability of an event can be adjusted as if a policy were tailored for that purpose, and the influence on the probability of the other events might then be examined (Gordon and Hayward 1968). According to e.g. Martino (1972, p. 272), the cross-impact matrix arose from an objection to the Delphi study. Nevertheless, Martino points out that it should not be confined to only examine interactions between Delphi forecasts. Instead, the cross-impact analysis can be used to analyse forecasts no matter how they are obtained and regardless of whether they come from the same source.

The Morphological field analysis was developed as a method for structuring and investigating the total set of relationships in multi-dimensional, usually non-quantifiable, problem complexes. Since then, the morphological analysis has been extended and applied to the field of policy analysis and futures studies (Ritchey 1998). The Swedish Defence Research Agency FOI (former FOA) developed a software, CASPER, to deal with multi-dimensional problems. In this tool, which is described by, e.g. Ritchey (1997), a kind of morphological field analysis can be used to integrate parts into different possible future scenarios. In this method, a set of inter-related variables (dimensions) are defined and their logical correlation is specified. Such variables can be geography, functional priorities, size and general philosophy as shown by an example regarding the future of the Swedish bomb shelter program (Ritchey 1997). Each variable is assigned a range of discrete conditions that it can express. Configurations containing one condition from each variable might then be constructed, forming some kind of description of a future state. A typical field can involve between 50 and 100 thousands of possible configurations. To reduce the number of outcomes and to exclude inconsistencies, pairs of conditions are evaluated as to their consistency through judgements. Focus is here on inner consistency or coherence, not on causality. Each combination containing inconsistent pairs is then excluded from the analysis. The remaining combinations, usually 100-200, can then be ranked and examined as elements of scenarios.

Some comments need to be made on the morphological field analysis. First, even though it aims to develop consistent scenarios, it could be used to test consistency as well. Elements of scenarios developed with other techniques might be fed into the computerised support system and be evaluated as to their consistency. Second, as the morphological field analysis is used by Ritchey and others, it also contains the generation of ideas since variables and conditions are determined within the analysis.

The consistency techniques described above are listed in Box 4.

Box 4. The consistency techniques that are highlighted in this work. The principal advantage of the consistency techniques lies in their ability to secure the consistency between or within scenarios.

Examples of consistency techniques:	
Cross-impact analysis	Morphological field analysis

5. Scenario types and the techniques

In this section the techniques and mixes of techniques are discussed in relation to the different scenario types. The same technique can be used for the development of different types of scenarios, although some adjustments may be needed. To some extent we discuss criteria for selection of techniques. We also try to point out possibilities and limitations with some of the techniques as regards their applicability on the scenario types. In Table 1, an overview is presented of the techniques we suggest as useful for development of different types of scenarios. As mentioned in section 4, several techniques are useful in more than one of the phases of scenario development (generating, integrating and consistency). In such cases they are listed according to their competitive advantage in our understanding. However, in the text that follows the broader applicability of the techniques is described.

Table 1. Contribution of techniques in the phases of scenario development. All techniques can be used in several phases but only their main contribution is mentioned in this table.

Scenario types \ Techniques	Generating	Integrating	Consistency
Predictive			
Forecasts	• Surveys • Workshops • Original Delphi method	• Time series analysis • Explanatory modelling • Optimising modelling	
What-if	• Surveys • Workshops • Delphi methods	• Explanatory modelling • Optimising modelling	
Explorative			
External	• Surveys • Workshops • Delphi modified	• Explanatory modelling • Optimising modelling	• Morphological field analysis • Cross impact
Strategic	• Surveys • Workshops • Delphi methods	• Explanatory modelling • Optimising modelling	• Morphological field analysis
Normative			
Preserving	• Surveys • Workshops	• Optimising modelling	• Morphological field analysis
Transforming	• Surveys • Workshops • Backcasting Delphi		• Morphological field analysis

5.1 Forecasts

Modelling techniques are natural tools for making forecasts that are made within a given structure. Time-series analysis and explanatory modelling are both commonly used for this purpose. Optimising models have been used to try to make predictions. For example, in Ahlroth et al. (2003, p 44) it is pointed out that the MARKAL-Nordic model, a model of the stationary Nordic energy system, has been used to try to predict how the energy system respond to Nordic trade on electricity and natural gas, emission trade permits and tradable green certificates. When MARKAL and similar models are used for predicting the future development, the prediction is based on various assumptions regarding future fuel prices, investment costs etc. It is also based on the rather strong assumption that the system will succeed to develop in an economically optimal fashion.

Explanatory models, as defined here, are based on causal links in the form of equations connecting variables and will, thus, only produce forecasts within a given structure. One method that tries to offset forecasting errors of causal models due to structural changes is intercept correction, described e.g. in (Hendry and Clements 2001).

One advantage with a computer model is that it is more rigorous and precise than an everyday mental model. Further, it is logically coherent and can include and process large amounts of information (Bell 1997, p. 281). Another benefit of model simulation is that more measures can be examined at a lower cost, or tested at all, compared to a real-world analysis. Modelling techniques thus provide quantitative, clear and consistent forecasts, often accompanied by a quantified uncertainty. However, the quantification of uncertainty in forecasts often depends on subjective assessments of the likeliness of various events. Human action is part of many forecasted systems. Other parts of the systems, such as weather systems, are chaotic. It is typically difficult or impossible to calculate the statistical likeliness of the behaviour of human individuals and chaotic systems.

All forecasts based on a model depend on the accuracy of the model and the accuracy or nature of the input data to the model. Bell (1997, p. 281) notices that there is a risk of false impression of validity when using a computer model because of its “precision” when in fact important aspects of real social systems are omitted from the model. A model typically also requires a large number of input data. There is a significant risk that the forecast be affected by measurement errors, errors in the interpretation of data sources, calculation errors, or writing errors.

Surveys and workshops could be used for generating additional information to quantitative models. They can also be used for generating and reviewing model structures, assumptions, input data, model calculations, and model results (Unger 2003).

Bell (1997, p. 271) states that as a forecasting technique, the Delphi method contributes additional information to data from other sources such as trend analysis from objective data or simulation. The Delphi technique both produce forecasts within a given structure as well as forecasts of a change of structure. Moreover, Bell (1997, p. 272), points out that the Delphi technique was created and survives because it is a cheap and quick way of getting the information needed for making decisions. It is at hand when a forecast must be made and there is shortage of data, inadequate models and lack of time or resources to make a thorough scientific study (Stewart 1987, p.102). Hence, the Delphi method is primarily useful when other studies cannot be done due to a lack of data, time or resources. It can also be useful when the complexity of the problem at stake is too big for ordinary forecasting. According to Simmonds (1977), the key weakness of a Delphi study is that certain questions might not be asked, because they did not seem important when the study was initiated. Another point of weakness, also concerning the questions, is that they may be ambiguous, trivial, biased or irrelevant (Bell 1997, p. 269).

The consistency techniques do not themselves create forecasts but both the cross-impact analysis and the morphological field analysis might be used to check the consistency among different forecasts, the cross-impact analysis focusing on causality and the morphological field analysis on possible co-existence. This should hold for different forecasts within the same structure and apparently also for forecasts predicting change of system structure.

5.2 What-if scenarios

The pros and cons of various techniques are the same for what-if scenarios as those mentioned for Forecasts above. The only difference is that some generating techniques may be useful when investigating which events the study should take into account when replying to the question "What will happen conditioned some specified events?".

5.3 External scenarios

External scenarios respond to the question What can happen to the development of external factors? This could be responded to both by models which are assumed to characterise some possible development of the system, or in a more qualitative way.

Generating techniques such as workshops have been frequently used in scenario planning (van der Heijden 1996). There are also ambitious studies that combine narrative storylines with several models of different dynamics, e.g. IPCC's Emission scenarios (IPCC 2000). The aim with using workshops in the scenario building process is both to generate ideas and information to the scenarios, and to structure the information in order to find patterns and key driving forces. Hence, the workshop technique is used for idea generation as well as for integration. One advantage is that workshops can facilitate broadening of the perspectives since both decision makers, stakeholders and experts can be included in the process. Moreover, workshops could increase the acceptance of decisions or scenarios among the participants. In the workshop process it is also possible to include techniques that liberate the creativity of the human mind. One risk when developing external scenarios in workshops is that the analysis can become too shallow due to time limits. van der Heijden (1996, pp. 189-190) points out that the analysis needs to be in some depth and that part of the work should include historical analysis of important variables. It is often useful to use surveys or panels as consultants to provide more input to the scenario development process. In the modified Delphi method developed by Best et al (1986), meaningfully different scenarios of alternative futures are elaborated.

It is possible to use both explanatory models and optimisation models for generation of external scenarios. Whether they create explorative scenarios and not predictive must depend on the assumptions underpinning the models. Time-series analysis is not proper since only one variable is projected and since it is explicitly based on historical values.

The consistency check technique Morphological field analysis might be used to develop scenarios of factors external to the actor in question. As the result is different possible internally consistent scenarios, they are an answer to the question "What can happen to the development of external factors?". One advantage with a morphological analysis is that it may help to discover new relationships or configurations, which may not be so evident, since it compels people to think of all combinations of included variables (Ritchey 1998). Another point is that this method manages some methodological problems inherent in developing futures scenarios and risk-management strategies: unquantifiable variables, uncertainty that cannot be specified and the lack of transparency in the process to reach conclusions. In essence, scenario development by morphological field analysis puts judgments on a formalised, traceable and solid methodological ground according to Ritchey (1997). Ritchey (1998) points out one possible weakness with Morphological Analysis; that it is too structured and might inhibit free, creative thinking. If developing the external scenarios by another method than morphological field analysis it is still possible to use the morphological field analysis to check the internal consistency of the scenarios, e.g. when a generating technique has been used to create the scenarios. The Cross-impact analysis could possibly be used to check the internal causal consistency within external scenarios if probabilities are attached to components in the scenarios.

5.4 Strategic scenarios

Explorative strategic scenarios explores consequences of strategic decisions. Several generating techniques can be applied to produce these kinds of scenarios. Workshops may be used to supply information and for structuring of ideas. Surveys, and Delphi techniques are also possible techniques. Both for generating options for strategic decisions and for exploring the consequences of a predefined set of possible decisions.

There exist examples where models are one of the components for generation of strategic scenarios. In the STEEDS project, explanatory models producing forecasts formed one part of a decision support tool for policy analysts. External scenarios developed according to the scenario planning tradition of

Shell and GBN are in the STEEDS tool linked to the models through quantified variables. Policy variables are also input parameters to the model system (Dreborg 2004, pp 43-44). Dreborg (2004, p.43) argues that the STEEDS decision support tool is a combined approach, and that the methodology in the STEEDS project differs from ordinary sensitivity testing because the input variables from the external scenarios adjust the modelling systems default way of working. It is possible to think of using explanatory modelling as well as optimising modelling when building strategic scenarios. Time-series analysis is not appropriate since only one variable is projected.

The morphological field analysis and the CASPER tool can treat policies and can, hence, be used to construct strategic scenarios (Ritchey 1997). It might also be possible to use the morphological field analysis to test the consistency of strategic scenarios elaborated with another technique.

5.5 Preserving scenarios

Both qualitative and quantitative normative preserving scenarios are made within a given explanation structure. Planning processes sometimes have an implicit or explicitly stated optimising aim. Planners or experts then make judgement on which is the most efficient path to reach a specific target or several targets. This path could be seen as a preserving normative scenario. Different methods and means are used to make these judgements, depending on the application of the decisions. The generating techniques surveys and workshops could be utilized. Panels could assist in accumulation of knowledge and surveys could be made to collect peoples' opinions on the matter. Workshops could perhaps also be used to accumulate and disseminate knowledge. Workshops and panels also increase the acceptance of the results among the stakeholders that are involved in the process.

Using an optimising model to find e.g. the most cost-efficient energy technology mixes, is powerful and also important as a learning tool. Optimising models such as MARKAL are many times used to look several decades into the future, see e.g. Unger and Alm (2000) and Unger and Ekvall (2003). The optimising modelling might be used as an aid to discover efficient paths towards certain goals, as e.g. certain limits of emissions to the environment or merely the cheapest energy system. The fact that the model can choose the cheapest solution and handle a large quantity of data is an important learning component.

One risk with optimising modelling is that the thinking might be stuck in present solutions, possibilities and limitations. One particularly important risk when using an optimising model in a normative way is, according to Ahlroth et al. (2003, p. 46), that the models miss solutions that are just a little more expensive but better in some other respect, e.g. the environmental performance or robustness. Steen and Agrell (1991) e.g. argue that it is pointless to optimise an energy system for several decades, e.g. due to uncertainty of input data.

Time-series analysis and explanatory modelling are not directly applicable since they do not explicitly optimise the system in an exogenously determined manner. But time-series analysis and explanatory modelling can be used to produce forecasts of the development of external factors. These forecasts might be utilized to provide background information for qualitative preserving scenarios since they give a hint of the direction of current development. Explanatory models producing what-if scenarios could also be used as a comparison to quantitative preserving scenarios.

The morphological field analysis could possibly be used to check the internal consistency of the qualitatively determined preserving scenarios.

5.6 Transforming scenarios

All normative scenarios work towards some kind of target. In normative transforming scenarios, such as the scenarios in a backcasting study, the changes required to reach that target are profound. Therefore, generating techniques are the basis in backcasting studies. The think-tank model was usually utilized in the early backcasting studies in the 1970s (Dreborg 2004, p. 25) and have been applied in most "soft energy" path and "sustainable society" backcasting studies (Robinson 2003). Structured brainstorming in a workshop format is often used.

In some recent backcasting studies, there has been a tendency to involve stakeholders in the process, see e.g. Robinson (2003), since stakeholder involvement is strongly emphasised in recent sustainability analysis . There are also recent examples of involving experts in backcasting studies (Carlsson-Kanyama et al. 2003). The involvement of experts and stakeholders might be done with different techniques. It can be advantageous to work with an expert and stakeholders panel in backcasting since the results and the thinking are more effectively spread (Bell 1997, p. 258). Moreover, several opinions may be heard, including more extreme positions (von Reibnitz 1988). One drawback of working with panels is that it is more time-consuming than working e.g. with the think-tank model.

One example where workshops have been used in the creation of scenarios for a backcasting study can be found in Carlsson-Kanyama et al. (2003) The workshop technique has the advantage of letting a broad group of people discuss desirable targets. It also increases the acceptance of the images of the future. A survey research may study peoples broad image of the future, e.g. their expectations, hopes and fears (Bell 1997, p. 258). In that case, it might be possible to use the result as a component in a backcasting study. Another technique to be used to formulate the images of the future in a backcasting study is the Backcasting Delphi method. The Delphi-procedure with repeated rounds provides an opportunity for incorporating of criticism and new suggestions in the scenarios, thereby hopefully ameliorating the scenarios (Höjer 1998).

As for integration, workshop techniques may be used to structure material from previous generating workshops. Also consistency testing is usually done in a qualitative way, by using expert panels to get critique and suggestions of improvement.

The modelling techniques are not well suited for elaborating the images of the future of a backcasting study because they do not consider large changes. However, they can contribute by indicating the direction of present trends, describing certain parts of the investigated system, etc.

The morphological field analysis could possibly be used to check the internal consistency of the images of the future, and perhaps also the consistency of the paths towards these futures.

6. Concluding discussion

As stated in Section 2, we distinguished three scenario categories based on the type of question that is posed about the future: *What will happen?*, *What can happen?* and *How can a specific target be reached?* Within each category, we identified two scenario types (see Figure 1). Different scenario types can be contained in the same study.[3] It can also be difficult to clearly categorise scenarios in practical applications. There is, for example, a grey area between forecasts and what-if scenarios, as well as between what-if scenarios and explorative scenarios. However, even if it is sometimes hard to clearly identify the type of a specific scenario, the categories and types can still work as landmarks identifying different kinds of studies. Such landmarks are necessary for anyone who wants to find their way in scenario studies.

In this paper, we adopted a user's perspective to scenario studies. Users include people who develop scenarios, use already existing scenarios, and/or receive information about scenario results (see Section 1). In scenario development, Section 2 can assist in structuring questions about the future, and Section 3 can provide some advice in the selection of scenario techniques. For people who use or receive information about existing scenarios, the report can assist in interpreting and evaluating the scenarios.

In this paper, we make a distinction between scenario types and techniques for building scenarios. Perhaps too often, a certain technique is chosen without much consideration when instead an initial discussion should concern the desired products, i.e. the types of scenarios that are wanted and needed. Table 2 summarises some of the discussions in the previous sections.

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[3] As an example, an energy report from IEA and OECD includes three external energy scenarios and one preserving scenario OECD/IEA (2003). Energy to 2050: Scenarios for a sustainable future. Paris.

Table 2. Summary of key aspects of scenario types

Scenario category/type	**Quantitative/qualitative**	**Time frame**	**System structure**	**Focus on internal or external factors**
PREDICTIVE – what will happen?				
Forecasts	Typically quantitative, sometimes qualitative	Often short	Typically one	Typically external
What-if	Typically quantitative, sometimes qualitative	Often short	One to several	External and, possibly, internal
EXPLORATIVE – what can happen?				
External	Typically qualitative, quantitative possible	Often long	Often several	External
Strategic	Qualitative and quantitative	Often long	Often several	Internal under influence of the external
NORMATIVE – how can a certain target be reached?				
Preserving	Typically quantitative	Often long	One	Both external and internal
Transforming	Typically qualitative with quantitative elements	Often very long	Changing, can be several	Not applicable

The characteristics described in Table 2 can be employed as a user's guide to help understand the type of scenario that is wanted and needed. This can be matched with Section 3 in order to choose between different types of techniques and better understand how the technique can be used in order to obtain the desired type of scenario. From Table 1, it can be noted that the same type of technique can be used in different ways in order to produce different types of scenarios.

If the user wants to predict the future, forecasts and what-if scenarios are of interest. If the user wants to think in terms of several possible futures, perhaps in order to be able to adapt to several different types of outcomes, explorative scenarios may be useful. If the user wants to search for scenarios fulfilling specific targets, and perhaps link this to actions that can be taken towards the visions, normative scenarios should be the choice. These three approaches to scenario studies are different. By emphasising the user's perspective to scenario studies, we argue that the choice of scenario category is not only a question of the character of the studied system. Instead, the user's worldview, perceptions and aims for the study can be even more important for the choice of approach.

Different views on the possibilities of predicting the future can also influence the choice of scenario types. For example, many forecasting and optimising models need input data in the form of prices and price elasticities. Some will claim that since these are uncertain, it is meaningless to use forecasting and optimising models for long time perspectives (Steen and Agrell 1991). Others may argue that such forecasts and optimising scenarios can still stimulate thoughts and debates and, hence, contribute to decision-making processes. As stated in Section 2, the choice between preserving and transforming types of normative scenario (optimising and backcasting) can depend on whether long-term targets are perceived as more important than short-term efficiency and on whether the user perceives the long-term targets as being easier to predict than fuel prices, etc.

For example, a researcher at a manufacturing industry and two researchers at the national Environmental Protection Agency (EPA) may all wish to study the energy system. The manufacturing company has little influence over the energy system, but may still be sensitive to changes in it. In such a case, explorative studies of the energy system can be valuable. One EPA researcher may argue that key aspects of the system seem predictable and that the possibilities to influence the system are small. If so, the reasonable way to study the future is to make predictions. The other EPA researcher may argue that there are good possibilities to influence the system. To such a person a normative study is more relevant. The types of knowledge that these three persons are interested in differ and the resulting scenarios are also likely to differ. This is not a problem as long as the user is aware of it, and states the starting points of the study clearly.

Moreover, there is sometimes a tension between the aim and the perspectives on the possibilities of influencing the future and the possibilities of predicting the future, for example when a user wants to investigate how a certain target can be reached, but does not know how, or if, the development could be influenced. Or when the user wants to predict something, but knows that the user's own actions will influence the actions of others, in a game-like situation. Both those situations are common and should not be disguised. They are not easily solved, but they occur and they should at least be openly declared.

It is possible, and sometimes preferable, to use a combination of techniques to create the desired scenario type. A technique with mainly qualitative elements and a technique with mainly quantitative elements can, for example, be combined to make a forecast. As for external scenarios, a generating technique might be used to provide input to different models. In strategic scenarios, one technique is usually utilised to generate external scenarios that form the basis for the strategic scenarios. In a second step, another technique may be used to identify and describe the available policy options.

The optimising models can be regarded as a combination of techniques. To make a model run, forecasts or assumptions of external parameters have to provide input to the model. Perhaps a refinement of assumptions of the future state of requested parameters would make the results of the tool more accurate or could expand the applicability of an optimising model as a planning tool. For example, if external scenarios elaborated with the scenario planning technique are the basis for the input to the model, the optimising model could contribute a more rigorous and precise development in the different external scenarios. This information would also be quantified, which is a necessary prerequisite for many other applications. It must be remembered, however, that the quantitative results are typically very uncertain.

In this paper, we suggest a typology of scenario studies and discuss techniques to generate scenarios. We base our typology on the idea that the scenarios should be of use to someone. As has been shown, such users can have widely different ideas on what kind of product, i.e. scenario, is desired. Therefore, continued work is needed in which potential users of the scenarios are given the opportunity to comment upon typology and technique discussions and to give their input on the demands of a user-orientated scenario guide. However, our hope is that the guidance already provided in this paper can be useful. One of the most important factors identified is probably the emphasis on the importance of the user's own rationale for using a scenario study.

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