Technical University of Denmark

Introduction to foresight and foresight processes in practice

Note for the PhD course Strategic Foresight in Engineering

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Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

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Technology and Innovation Management

DTU Management Engineering

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Foreword

This text is intended as a note for the PhD course, Strategic Foresight in Engineering. The text has three parts: First, as foresight is a quite ambiguously defined and understood entity, we shortly present our understanding of what foresight is. The second part is an introduction to foresight processes in practice. Finally, the text present a few selected foresight methods that are commonly used in Denmark.

The text is based on parts of the publication: Per Dannemand Andersen & Birgitte Rasmussen; “Fremsyn: Metoder, praksis og erfaringer”, Styrelsen for Forskning og Innovation, København, February 2012. ISSN: 978-87-92776-28-0

Introduction to foresight

What is foresight?

Foresight is about relating to the future in a qualified and active way.

During recent decades, many great changes in society have had decisive significance for future developments on all levels. Some of the changes are long-term and predictable. This applies, for example, to greater longevity, increasing resource consumption, China's growing economic importance, globalization, population growth and shifts in the world's population.

Other changes are due to sudden and unforeseeable events. Such changes are for example the oil embargo in 1973, the catastrophic nuclear accident in Chernobyl in 1986, the attack on the World Trade Centre on 11 September 2001, and the 'Arab Spring' in 2011. We have already experienced some of the consequences of these events. We can still expect others.

Sometimes, there are changes that in the course of a few years cause dramatic changes in society's development, in enterprises and our daily lives. This applies, for example, to the rapid spread of computers, the internet, mobile phones, Facebook and Twitter. Some technologies grow old, while new technologies change society and create new business opportunities. It is as if changes happen more and more rapidly and have greater and greater effects. The ability to relate to future changes and possibilities is in many ways crucial. This is true for countries, public institutions, enterprises and organizations and for us all as individuals.

Changes are, however, not always given and impossible to influence. This is true within the contexts of both society as a whole and business. Future developments can in many ways be influenced and formed, but this demands a coordinated effort by many actors who work toward the same goal. For example, many investigations have shown that enterprises can in the long term achieve competitive benefits, if they contribute to creating future development (Hamel and Prahalad, 1994).

The goal of foresight is not to predict the future, but to discover the perspectives of many different futures and make decisions today. Foresight is therefore based on two premises: that there is not one future but many possible futures; and that it is possible today to make choices that influence future developments. At the same time, it is decisive to include relevant actors in the process and in decision-making who can lead development in the desired direction.

Foresight is an area of practice and theory under marked development, and over the last decades, the area has developed into a mixed collection of methods, processes and aims. Foresight's methods are often termed Prospective Technology Analysis Methods or Strategic Intelligence Methods. In some contexts, the term foresight is identified more with these methods than with their use. Thus, numerous definitions of foresight exist. In this publication, foresight is defined a *systematic, future-oriented, analytical and interactive process that partly contributes to shared visions concerning long-term developments within science, technology, business and society and partly facilitates the alignment of relevant stakeholder groupings around desirable developments through relevant strategies, decisions and actions*[1].

The aim of this publication is to describe the present status of experiences with foresight and with the use of foresight methods in international and Danish contexts. The aim is also to spread knowledge of foresight methods and contribute to the knowledge base in relation to future foresights in Denmark. It is hoped that the publication can function as a general introduction to foresight and foresight methods.

[1] Definition based on reflections during a Nordic project about whether there is a special Nordic approach to foresight (Dannemand Andersen et al., 2007).

The publication is based on knowledge gathered from reports, articles, homepages etc., as well as the two authors' personal experiences with foresight. Thus, further evaluations and analyses have not been carried out in connection with this publication.

Foresight's roots

Foresight is often considered an area of practice based on three more established traditions: technology forecasting, futures studies and technology assessment.

Technology forecasting means predicting a future technological development. This tradition has its roots in the aftermath of World War II, when the American military needed a systematic method for making an informed judgment regarding the rapid technological development and its significance for military defence. Institutions like RAND and Batelle were central in method development. In the 1940s and 1950s, large American enterprises developed systematic decision-making methods for technological strategic development based on such disciplines as strategic planning, operation analysis and econometrics. During the 1950s and 1960s, forecasting was developed as a broadly accepted tool by large enterprises, international organizations and in many countries' governmental administrations (Jantsch, 1967).

The tradition of futures studies is attributed especially to French academic communities in the mid-1960s around such persons as Gaston Berger and Bertrand de Jouvenel. The Norwegian, Johan Galtung, is also considered a pioneer. These communities were partly characterised by a pessimistic and critical attitude toward the future and the technological development (Miles et al., 2008a+b). In future studies, the work is considered more a craft or an art form that requires creativity, imagination, new thinking and action (Martin, 1995, p158; Krawczyk and Slaughter, 2010). Future studies are often concerned with great societal challenges and large international trends and megatrends. Their function is also to create general debate, whereas forecasting is often used in concrete decision-making processes in enterprises and public contexts.

Some definitions

Technology Forecasting: "..*the probabilistic assessment of future technology transfer, which here denotes the entire range and effectuation of impact in technological as well as non-technological (economic, social, military, political, etc.) terms*" (Jantsch, 1967, p17)

Futures studies: "*.. to discover or invent, examine and evaluate, and propose possible, probable, and preferable futures*" (Bell, 2003, p73)

Foresight: "*.. a systematic, participatory, future-intelligence-gathering and medium-to-long-term vision-building process aimed at enabling present-day decisions and mobilising joint actions"* European Foresight Platform, 2011)

Through its point of departure in technology criticism, future studies seem to have formed the basis for a third tradition, technology assessment (Miles et al., 2008a+b). This involves a systematic assessment of the consequences for society and human beings of the introduction and use of new technology. Technology assessment became institutionalised when the Office for Technology Assessment (OTA) was established in 1972 by the US Congress. It was closed again in 1995. Technology assessment institutions are found today in several European countries. Technology assessment has especially contributed to foresight with participatory methods. In this context, participatory method means broad inclusion of citizens in the discussion and assessment of the future development of technology and of the challenges to society. In this respect, the technology assessment tradition differs from both technology forecasting and future studies, both of which are expert-oriented and elitist.

Modern use of foresight is often said to have its roots in Japan, which in the 1970s experienced very successful economic development based on research and technology. One of the reasons for this is attributed to conscious research and technology policy priorities based on comprehensive technological foresight projects that were started at the end of the 1960s (Kuwahara, 1999). Japan has since 1970 regularly carried out large Delphi-based technological foresight projects with a 30-year time horizon and with inclusion of thousands of experts.[2] In most large OECD countries during the 1980s and especially in the 1990s, great interest arose for national technological foresight and its use in setting public research policy priorities. Technologically advanced countries like Japan, Germany, South Korea, France and Great Britain have had foresight programmes since the beginning of the 1990s. Since 2000, several smaller countries (like Portugal, Cyprus and Denmark), the new Central and Eastern European EU member countries (like Czech Republic, Poland and Romanian), and the growth economies in Asia and Latin America (like Brazil, Venezuela and Chile) have carried out various national foresight projects (Miles et al., 2008a+b).

Who uses foresight and for what?

Foresight is used in both the private and public sectors, and at the international, national and regional levels.

Since the 1950s, many large international enterprises have used forecast techniques in internal planning processes. In connection with the crises in the 1970s, more enterprises became aware that projections were not applicable to situations with great, externally caused upheavals. Instead, the enterprises directed focus toward preparing themselves for several different futures. One well-known example is Shell Oil, which considered, for example, how the firm should react to possible increases in oil prices through the use of scenario exercises. In this way, the firm achieved strategic preparedness when the first oil crisis occurred in 1973. In recent decades, enterprises' use of foresight has changed again. In the 1970s and 1980s, foresight was often used in connection with preparing the enterprise for unforeseeable future developments, whereas foresight's use today is often more active, aiming to influence future development. Enterprises' use of foresight thus follows the development in leadership practice within industrial innovation and strategic planning (Reger, 2001; Daheim and Uers, 2008). Today, enterprises primarily use foresight methods as general support for making strategic decisions. Foresight is also used to improve enterprises' long-term planning, early warning in connection with difficult situations (issue management), learning and innovation processes and the general ability to react to changes in the strategic surroundings (Daheim and Uerz, 2008). Foresight processes are also used to involve broader actor groups (customers, suppliers, researchers, competitors, NGOs etc.) in joint strategy development and innovation.

Foresight is used as a tool to develop business sectors and branches. A well-known example is National Technology Roadmap for Semiconductors, where the otherwise competing members of the American Semiconductor Industry Association joined forces to make long-term plans for technological development and to coordinate necessary research. In EU, the European technology platforms perform the same function. The platforms are established by all the important actors related to a technological area, with participation by enterprises, sub-contractors, universities, research centres, interest organizations etc. The platforms are led by the industry with the following aims: 1) to create a common vision; 2) to formulate a research strategy; 3) to formulate a market development strategy; and 4) to prepare large European initiatives in which public/private partnerships can implement research and market development strategies.

In many countries, foresight is used on the regional level. Newer innovation research has shown that regional conditions are important for the innovation capabilities of countries, regions and enterprises (Asheim and Gertler, 2005); therefore, foresight is used as a business and innovation policy tool for developing business clusters and regional and business development plans – for example, in Great Britain and Norway. In Denmark, similar methods are used in connection with regions' and municipalities' development planning of both cities and the open land.

Many international organizations use foresight. The International Energy Agency (IEA) makes scenarios and projections for energy technologies every other year (Energy Technology Perspectives). World Energy Council does something similar and on this basis proposes new energy and research policy initiatives. Intergovernmental Panel on Climate Change (IPCC), an organization under UN, makes scenarios as far in the future as 2100 for CO_2 emissions, climate change, rising sea levels etc. The material from IPCC provides

[2] See more about the Delphi method in the method section.

an important basis for climate policy worldwide.

Foresight and foresight methods are increasingly being used on the national level throughout most of the world. The increased use of foresight is perhaps inspired by New Public Management, which has focused on modernising and market-orienting the public sector since the 1980s. The increased use can also be seen in the light of many countries' wish for a more cohesive science, technology and innovation policy. The literature often names five aims for using foresight in this context (Georghiou and Keenan, 2006).

First, foresight is used to set priorities for research on the basis of future technological possibilities and future societal challenges. In the Danish context, FORSK2015 can be named as an example of the use of foresight.

Second, foresight can have the aim to re-orient national, regional or sectoral research and innovation systems. This has been the aim of a few national foresights in Central and Eastern Europe, where foresight has been used, for example, to change the research policy focus from material research to bio-scientific research, and to investigate new institutional structures. In the Danish context, parallels can be drawn to the resource area analyses and business cluster analyses that were carried out for the Business and Construction Agency.

Third, foresight can aim to create awareness regarding really big future challenges to society (Grand Challenges) and to function as an exhibition window for the results of and potentials for research and new technology.

The fourth aim is to bring new actors into the debate on research, technology and innovation policy. Here, greater emphasis is placed on the foresight process itself than on the results of the process. This foresight aim is perhaps especially interesting for countries without tradition for parliamentary technology assessment.

Fifth, foresight can have the aim to develop new networks and cooperation across scientific areas and industrial sectors or in relation to societal challenges. Like the fourth aim, there is more emphasis here on the foresight process than on the results of the process. The aim is to create new networks and competence clusters that break with traditionally existing disciplinary or sector-specific ties.

In practice, foresight projects often have several of the aims described above.

Foresight as an academic discipline

Parallel with the establishment of foresight as an area of practice in public policy development and enterprises' strategic planning, foresight is also developing into an academic discipline. The publication, "Toward a new Knowledge Area" from Norway's Research Council, states that foresight in Norway during the period 2003 to 2009 has developed qualitatively from a "competence milieu" to a "knowledge area" (Norges Forskningsråd, 2010b).

With regard to research, scientific interest in foresight has increased markedly since about 2005. The most important research milieus are naturally found in countries like Great Britain, Finland and Germany, which have large and longer-lasting public foresight programmes.

A complete search in SCOPUS for the word 'foresight' in titles, abstracts or as key word gave 2538 hits (5 January 2011). This result illustrates that scientific literature in the area has been markedly increasing during recent decades (see Figure 1). A relative search produces a similar result, also when it only includes key relevant journals.[3]

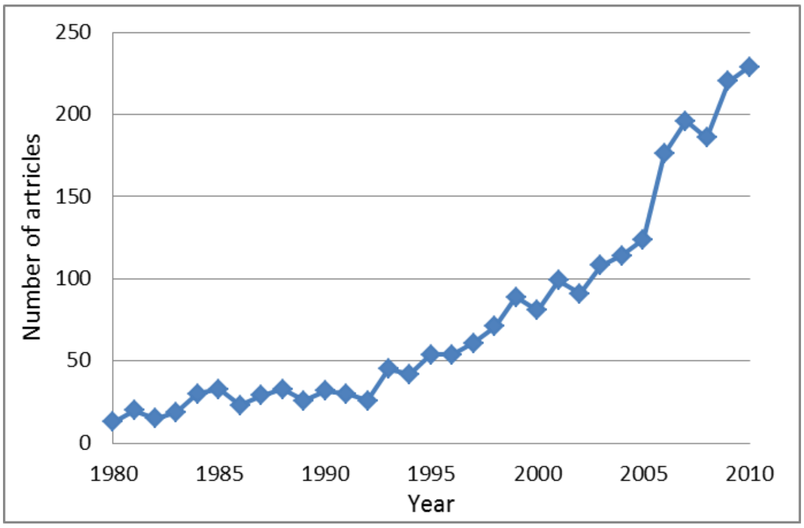


Figure 1. Development in the number of scientific articles per year with the word 'foresight' in the title, abstract or as key word. Source: search in SCOPUS on 5 January 2011.

An increasing number of graduate studies in foresight and similar fields are offered throughout the world – for example, in Australia, USA, Canada, Finland and Norway. Courses for practitioners are found in many more countries. The most well established course is offered by Manchester Business School.

International conferences within related disciplines have an increasing number of sessions related to foresight. A few international conferences are targeted foresight, especially the EU-sponsored conferences held about every second year in Seville with the title, "International Seville Conference on Future-oriented Technology Analysis (FTA)".

The scientific literature has until now been mostly descriptive and explorative. Foresight's theoretical foundation is still being discussed in the literature, which generally recognizes that there is a gap between practice and theory in the foresight field (Hideg, 2007; Fuller and Loogma, 2009).

3 Several international journals have foresight as a core area, primarily *Foresight* published by Emerald and *International Journal of Foresight and Innovation Policy* published by Inderscience. Established journals like *Futures* and *Technological Forecasting and Social Change* (TFSC) as well as *Technology Analysis and Strategic Management* (TASM) are also important. The French-language journal *Futuribles – Revue d'analyse et de prospective* should also be mentioned as the most important non-English-language journal.

Foresight processes in practice

A foresight process can be organized and implemented in many ways. The organization depends on both its goal and context. The context includes the overall decision-making or political process of which the foresight process and its results are a part. In the application-oriented part of foresight literature, various proposals are made for organizing foresight processes (e.g. Popper, 2008b; Hines and Bishop, 2006; Jørgensen et al., 2002); therefore, no one, generally valid description of the organization of foresight processes in practice is found.

Overall, foresight can be divided into vertical and horizontal foresight. Vertical foresight has a limited focus on a specific technological area, branch, sector, geographic location etc. The goal of vertical foresight can be to point out, substantiate and describe the potentials and development opportunities within the actual focus area. Horizontal foresight is broad, embracing a wide range of subjects and issues. Horizontal foresight is characterized by going across disciplinary and institutional boundaries – for example, between administration and ministry – and it differs from vertical foresight in that it includes a broad (ideally, total) list of societal possibilities, challenges and themes. Both vertical and horizontal foresight inspire decision makers to new thinking in relation to uncertainties and new development opportunities.

The foresight process often combines three main types of questions:

- Point of departure: How does the situation look now? This can also include mapping and analysis of the actual innovation system or thematic class. Especially the innovation system approach can prove to be useful. Just a simple model can be sufficient for understanding the actors involved, networks between these actors, and how knowledge is formed and spread between actors. It provides a good basis for focusing foresight processes and selecting participants.

- Wishes and expectations: What do we wish and expect of future developments within foresight's focus areas? They can include a combination of visions, development of plausible scenarios, and exploring changes within the framework of external conditions.

- Realisation: How do we realise the desired development? This includes an analysis of the instruments that are especially suitable for realising wishes and expectations for future development based on the present situation. Maybe the question is actually: What tools do we have in our toolbox?

Very few analyses are to be found regarding the general conditions that ensure successful completion of foresight projects. One of the few systematic analyses has studied foresight projects carried out by national authorities in nine countries (Calof and Smith, 2010). This study identifies eight conditions that have great importance for the success of foresight projects (see Box 1).

On the basis of Danish experience, three important elements can be added in relation to the process itself. First, a clear distinction must be made between decisions and analyses in the process. A foresight is not only an analytical process. While the process is underway, it is also necessary to make decisions that markedly influence the result of the foresight. This applies, for example, to the choice of steering group members, definition of the foresight's subject, and setting priorities. Second, openness and transparency must exist throughout the process in order to ensure the foresight's

Box 1. Conditions for successful foresight projects carried out by national authorities (Calof and Smith, 2010).

1. Focus on a clearly identified client.
2. Clear link between foresight and today's policy agenda.
3. Direct links to senior policy makers.
4. Public-private partnerships.
5. Develop and employ methodologies and skills that are not usually used in ministries and government agencies.
6. Clear communication strategy during the whole process – i.e. more than just dissemination of results.
7. Integration of stakeholders into the foresight project.
8. The advantages provided by existing national or regional academic receptor and training capacity.

legitimacy. Third, considerations concerning the possible instruments to be used to implement the foresight's results should be included in the foresight process itself, so that the results can be organized and targeted in relation to the possible means. Foresight sometimes ends with only a series of recommendations that have no real effect. The reason for this can be that the instruments are not sufficiently considered and investigated. Another reason may be that the foresight process' initiator or target group often only has a limited range of instruments at their disposal.

Foresight's phases

In this section, some of the important aspects are described of organizing foresight within such specific areas as technology and research or the great challenges to society, as well as regions, business sectors or branches. The point of departure is in vertical foresight, which is its most widespread form. The special conditions that exist in connection with organizing horizontal foresight are also described.

A foresight process is systematic and has three related phases, each of which contains some sub-phases (see Figure 2). The planning phase comprises preparation and organization of the foresight. The main phase is the most comprehensive and, in relation to time, the most labour-intensive part of the foresight process. It is in this phase that sustainable knowledge, visions and future possibilities are developed and priorities are set among the formulated possibilities on the basis of well-described criteria. The main phase can be divided into the following sub-phases: mapping, foresighting, prioritizing and planning (establishing an action plan). The follow-up phase is closely connected with the first considerations in the planning phase. It is not just a matter of publishing results after the conclusion of the project; the results should be presented and the dissemination organized with clear focus on the foresight's target group and clients. Finally, a systematic summary should be made of experiences and lessons learned.

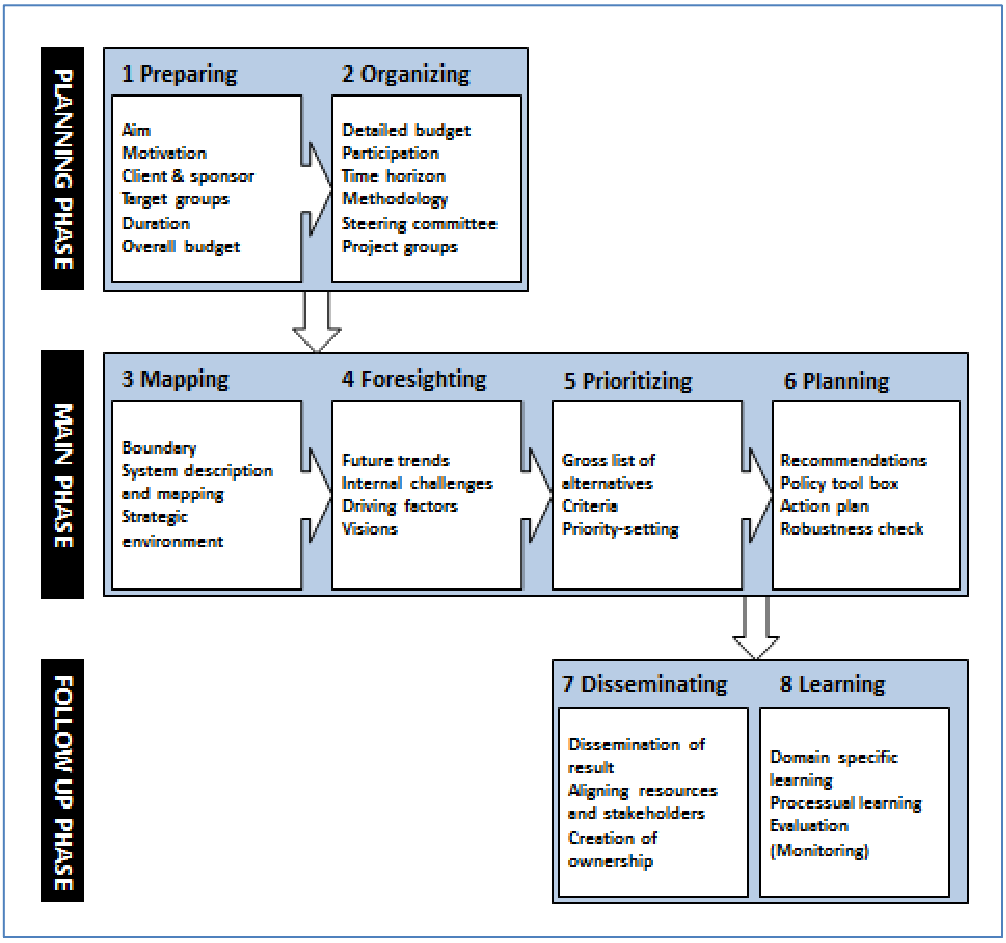


Figure 2. Phases and examples of elements in a foresight process.

Preparation

During preparation, the overall framework for the foresight process is clarified. The framework is often given, but it is important that it is described and clear to the directly involved parties.

Preparation also includes an alignment of the main actors' expectations, including considering how the foresight's results, recommendations etc. are to be used and implemented in concrete terms. It would be expedient to define the success criteria for the foresight itself already from the start, as well as the indicators for the foresight's expected subsequent effects.

In the preparation phase, several conditions should be clarified.

The aim of the foresight must be clearly defined. Early international experiences with foresight have already emphasized that the aim should be very clearly described in order to prevent certain interest groups from 'highjacking' the project in order to advocate their own viewpoints (Martin, 1995).

The motivation for the project – whether explorative or normative (Porter, 2010) – influences the overall rationales for the foresight. Explorative foresight is 'forward-moving' with the present as its starting point. The intention is to identify and draw attention to great possible future changes; it is not to achieve a specific desired state or final goal. Normative foresight, on the other hand, is 'inward-moving' and seeks to identify paths of development toward one or more beforehand-desired state(s) or future(s). The motive thus has great importance, especially in the follow-up phase

Foresight projects usually have a clearly defined client who is responsible for the overall organization of the process, and who preferably represents the organization, institution or group that will use the results. The project's client is often also the project's sponsor, meaning the organization that is financing the project. Sponsors and clients can also be different, and foresight projects can be financed by one or more sponsors (see also Box 2).

Target groups are often obviously a consequence of the foresight's motivation and goal. The target groups are the persons or organizations that are expected to use the foresight project's results: public institutions, public officials, politically elected representatives, enterprises, universities and research institutions, interest organizations etc. If the client does not clearly define the target groups, the implementation phase can contain an actor analysis. The target group ought to be clearly defined beforehand – and be involved from the start – to ensure ownership of the foresight.

> Box 2. Actors and formal roles in a foresight process
>
> 1. The client or the project owner is responsible (decision maker) for the overall framework for the foresight: aim, duration, type of results etc. Most often the client is also the sponsor.
> 2. The steering group represents the client in the foresight process and makes decisions regarding carrying out the foresight. The steering group acts as a management board for the project team.
> 3. (Expert)panels comprise persons with knowledge of special relevance for the foresight or for parts of the foresight. Their aim is to contribute knowledge to the process. In some cases, the steering group and panel can be the same group.
> 4. The project team or project group is the unit that carries out the foresight in practice and works between meetings in the steering group and panels. The team typically comprises 2-6 persons. The project team should have both methodological competences and competences in relation to the foresight's objects of study.
> 5. The chairpersons of the steering group and the panel are central actors whose personal qualities as meeting leader, facilitator, disseminator and political actor can be crucial for successful implementation of the foresight and its results. It is desirable to ensure the chairpersons' engagement, either through a salary or by choosing a person with a strong personal or professional interest in the project.

The clients often determine the duration of the foresight process (the time available before the results are to be presented). The time available is an important parameter when choosing method and organizing the implementation phase. In practice, larger foresight projects often have a duration of about one year.

Organizing

In this sub-phase, the foresight is organized in detail. The steering group or project team addresses the detailed budget, methods, involvement of participants, participants' institutional affiliation, number of participants and the foresight's time horizon. It is also recommended that in the organization of the foresight consideration be given to a method for collecting the experiences of each phase in the foresight, and to how this knowledge can contribute to the foresight area's continued professionalization.

In the organizing phase, the following aspects must be addressed.

The planning phase always contains considerations concerning the budget that cover the foresight's direct costs. The overall budgetary framework often is established already in the preparing phase; the organizing phase would then deal with the detailed budget. The direct costs include expenses for the steering group, project team, analyses, meetings, travel etc. In practice, it is often difficult to estimate the total cost of a foresight process. This is especially true for the time resources that the actors involved invest in the process.

Participation in the foresight processes can be open (extensive) or closed (exclusive) (Salo et al., 2008). Open (extensive) participation involves a larger number of persons or can be a completely open invitation to everyone who wishes to contribute to the process. The aim can be to give all viewpoints the opportunity to be formulated or to create ownership of the foresight's results among a broader circle of actors and stakeholders. A closed (exclusive) participation involves a smaller circle of especially selected participants. The aim can be to ensure a quick and effective process that ensures a balanced representation of different groups of actors and stakeholders, or in special cases, to ensure confidentiality and secrecy. The number of participants in the foresight process expresses the breadth of the foundation on which the foresight rests as well as how well known the foresight is. It can be difficult to gather reliable information about how many people have participated or contributed to the foresight in one way or another – in work groups, expert panels, workshops, questionnaires, open meetings etc. It can often amount to several hundred persons. Differences in participants' institutional affiliation support diversity in the collection of knowledge and viewpoints. In order to ensure difference, representatives could come from: research institutions, consulting firms, industries and businesses, public authorities and administration (ministries, regions etc.), professional associations and federations and others (NGOs, individuals).

The foresight's time horizon is a central issue. Foresights are often spoken of as short-term (1-5 years), medium-term (3-15 years), long-term (more than 20 years) and very long-term (more than 50 or 100 years). Choice of time horizon depends on the focus area and the goal of the foresight. For example, foresight for areas that are difficult to change, such as infrastructure and energy supply, has a different time horizon than foresight for areas that can change quickly, such as information and communication technology. In practice, foresight processes often look towards the future in the long term or medium term, but set up possibilities for action and recommendations in the short term.

The organizing phase also contains the choice of methodology for the main phase. The foresight's aim, budget and duration are the most decisive factors for choice of methods. The budgetary framework has special significance for the possibilities to involve expert and consultant assistance as well broader involvement of actors. Other factors – for example, data accessibility – can also play a role in choice of method. The following elements influence considerations related to which method should be used:[4]

- *Duration (calendar time):* The amount of time available before the results shall be delivered is of course an important factor in choosing method. The benefits of many methods can be improved significantly if

[4] See also the next section and the method databases FOR-LEARN and UK Foresight HCS Toolkit, which are on the internet.

the process is divided into smaller defined parts that can be carried out during the course of months or years, with the opportunity for reflection and further development between each part.

- *Expertise*: Different methods demand very different competences on the part of facilitator and participants. Some methods are relatively easy to use and can be applied without special prerequisites, while others demand specific professional, personal and processual competences. In each case, it is recommended to carefully consider whether the necessary expertise is available, since both results and resource consumption are directly dependent on this. The economic expenses are naturally dependent on the competences required of the facilitator and participants.
- *Labour (time)*: The salaries or fees of some of those involved are paid by the project, while others participate without payment but with the clear expectation of personal benefits from their unpaid efforts, which can involve planning, facilitation, processing, writing reports or expert notates, administration, meeting preparation, data processing etc.
- *Cost*: A broad range of expenses is incurred in connection with each of the methods and activities in a foresight. Some of the most important are salaries, fees, rental of meeting facilities, travel expenses, food, purchase of reports, PR activities, purchase of data and software, and consulting services.

Finally, the organizing phase includes appointment of a project team and, if needed, a steering committee. See Box 1.

Mapping

This sub-phase aims to define the boundary of foresight's focus area and the strategic environment. The sub-phase involves defining the focus area of the foresight as well as what lies outside this area. The focus area can be an area of technology, such as nanotechnology or robots. It can be a geographic area, such as a region, municipality, a city or a whole country. It can be an industrial sector, such as the service sector, dairy sector or the wind turbine industry. It can also be a single enterprise or a business unit in an enterprise. Basically, the focus area can be seen as that which we want to and can affect and change; whereas that which lies outside this area comprises the strategic environment, which it is not possible to affect (see Figure 3).

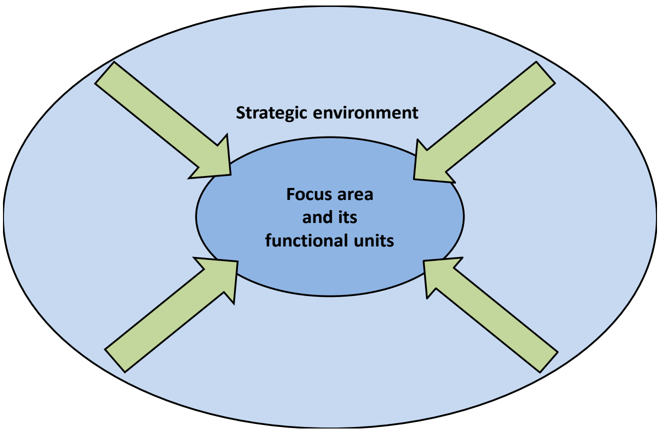


Figure 3. Defining the focus area and the strategic environment.

This sub-phase also comprises a more detailed mapping and description of the area of focus. If it is a business sector, a simple innovation system description can be used. Another approach is to use a relevance tree, which is a highly structured hierarchy of the parts of the actual focus area. The disadvantage of the relevance tree is that even quite simple focus areas easily become rather chaotic, the most important aspects drowning in the many details. A third approach is to allow an expert panel to carry out one or more brainstorms to find out which elements the selected area includes, and then intuitively assemble these in groups. The advantage here is that experts within a technological area can usually quickly describe the area's important elements. The disadvantage is that the description risks being incomplete.

It is not possible to make general guidelines for the mapping structure. Some of the mapping principles that have been used include: lifecycle or chain of value considerations, scientific disciplines, product and market areas, physical/chemical characteristics, generic technology groups and technological clusters.

The description of the focus area often also contains mapping of the actors involved as well as mapping of the positions of strength that are specific for Denmark, a region or a branch. Positions of strength can be mapped with the help of qualitative evaluations or quantitative data, such as patent analyses, bibliometrics, market share etc.

Defining the boundary and describing the focus area is often more difficult and time-consuming than expected. If the focus area is new or weakly defined, this sub-phase can take as much as half the time and resources available for the foresight.

The result of this sub-process forms the basis for the rest of the foresight process; therefore, the involved parties should agree to the greatest extent possible. The description and mapping of the focus area is however not only an analytical process. Disagreements can arise among the actors involved regarding limitation, description or status description; in such cases, the steering group, for example, must make the necessary compromises or make decisions in some other way.

The factors in the strategic environment of course affect the focus area. Strategic 'scanning' is a common term for methods used to clarify and monitor developments in the strategic surroundings – for example, an enterprise, branch, region or technological area. The aim is to capture early signs of significant imminent changes. A STEP analysis can be used as a checklist to support or organize the search for development tendencies. STEP stands for Social, Technological, Economic and Political. STEP factors are sometimes expanded with E for environment, L for legal, and V for values. They serve to help remember the different types of external trends.

Searching and monitoring significant trends in the strategic environment can be done through relevant professional literature, journals, homepages, newspaper articles etc. Simple analyses in patent databases can often provide an indication of the direction of technological development (Millett and Honton, 1991). Modern patent databases can also provide information on persons, enterprises and countries active within a given area. The internet, large databases and fast computers can be used for data mining, which is one of the new tools for strategic scanning. Searches can also be carried out by expert panels. A few large international enterprises have established actual 'shadow' groups in relation to specific development tendencies; such shadow groups draw on large intelligence networks.

Foresighting

This sub-phase looks into the future. The aim is to define driving factors, trends and visions for a future development, as well as to arrive at an understanding of dynamic relationships between contexts, the questions posed, trends and driving factors. Driving factors are factors that can either move a certain development forward or inhibit it. The search includes potential future problems, threats and opportunities, also those that lie on the edge of our present way of thinking and planning. The search includes both existing and recognised problems, tendencies and weak signals, and new and unexpected circumstances. The analysis can embrace both the focus area and the strategic surroundings.

This sub-phase is explorative, and the process must here make room for a diversity of viewpoints and contributions from both experts and laypersons. In this connection, it is important to be aware of the involved experts' and laypersons' understanding of the context and to clarify eventual differences of opinion. The foresight must also consider the reliability and quality of the sources used. In relation to method, a broad range of foresight methods are available: literature reviews, trend analyses, mega trends, key technology lists, scenarios and expert advice through expert panels, expert notates, Delphi etc.

The collection and structuring of the diversity of viewpoints, contributions, data and information are organized on the basis of the established description of the focus area.

Especially for horizontal foresight, this sub-phase can be particularly demanding of resources to carry out both the collection and structuring of viewpoints, contributions etc. The search here goes across thematic limitations, but it can be useful to organize the search process in relation to predefined categories. Technological subjects and societal challenges are to a great extent valid globally; therefore, this search is often based on European and international foresight studies. For subjects within the business sector, it is to a greater extent Danish circumstances that are the source of subjects. For foresight within the public domain, the gross list of subjects stem in principle from all areas of policy and responsibility in the state, counties and municipalities. The gross list is then structured into a few cohesive themes that are qualified in relation to each theme's significance for the country, region, branch or enterprise. Special attention should be paid to possible relationships between the different themes, since solution possibilities can go across several themes.

The identified development tendencies and driving factors can be constructively challenged by comparing the sub-phase's results with international investigations. Such a comparison demands that the choice of method be considered, in order to be sure it is practically possible. Appropriate methods can be, for example, Delphi, key technologies, SWOT and expert panels. Another possibility is to discuss and create dialogue regarding the results with actors on different levels of the focus area as well as laypersons and untraditional thinkers who in one way or another can provide the steering group with a qualified and constructive challenge.

The result of the sub-phase is deeper understanding of the significant driving factors, development tendencies and visions in relation to the actual context and issues. Since the sub-phase is exploratory and open, it is often not possible to achieve consensus or make a formal report. This is first possible in the next sub-phase.

Prioritizing

Whereas the foregoing sub-phase is exploratory and unfolding, this sub-phase is focusing and priority-setting. From a gross list of alternatives it aims to select and substantiate the areas to be worked on and their perspectives in relation to the foresight's goal.

In this sub-phase, a limited number of criteria for evaluating, focusing and setting priorities in relation to the whole foresight's overall rationale and goal are considered. The criteria should be defined and described in a transparent process and disseminated in an easily accessible way. If the principles and criteria for the priority decision are unclear, or if it is unclear where they stem from, it can be difficult later to create legitimacy for the foresight's results. Choosing criteria, and focusing or setting priorities in relation to these criteria, are therefore not a purely analytical task, but a decision that, for example, a steering group makes among the presented alternatives and with respect for the foresight's goal.

In many foresight processes, the idea is to be able to point to research and technology areas of special interest. It is thus assumed that some areas are more meaningful than others, and the criteria for this can be established in different ways. A prerequisite for doing this, moreover, is that a gross list of areas can be made, among which priorities can be set. The criteria often have the character of SWOT analyses.[5] On the one hand, there are future technological/industrial opportunities and great societal challenges and threats; on the other hand, there are the existing national, industrial or regional strengths and weaknesses for exploiting opportunities or meeting the challenges (Keenan, 2003). Few easily understood and thoroughly thought out criteria are more operational than a large number of criteria that seek to include a broad range of considerations in the priority-setting process.

5 SWOT analyses are briefly described in a later section.

The discussion and choice of criteria is a central part of a foresight process. The technical formulation of criteria is probably a job for experts, but the discussion of the criteria's content can involve a broader circle – for example, recipients, customers and follow group. It is also important to substantiate the choice of criteria in order to create transparency, reliability and legitimacy in the process. As mentioned above, the choice of criteria and the final priorities set according to these criteria should be decided by a steering group or the like.

In relation to formulating the concrete choices and rejections of criteria, participants from academia often have a certain lack of experience, or sometime also resistance, with regard to becoming obligated in a strategy or priority-setting process. Some reluctance can exist to being connected with concrete priorities and recommendations. No simple way exists to counter this, but in planning a foresight process, it can be ensured that sufficient time is given to this part of the process.

This sub-phase results in a well argued and negotiated list of recommended priorities for the areas to be worked on and their perspectives, based on clearly formulated priority-setting criteria.

Planning

In this sub-phase, a synthesis is made in order to translate recommendations and priorities into possible actions and efforts. The essential aspect of this phase is to point to and substantiate the areas to be worked on that can be beneficial to pursue within the relevant area, and their perspectives.

This phase can also include identification, evaluation and discussion of the different means (management or policy toolbox) that are actually available for implementing the recommendations. For example, regional foresight has the problem that the regional clients do not themselves have sufficient means at their disposal. The means are often limited to establishing networks and limited public purchases. Powerful means like establishing research institutions, research programmes and tax and duty policies are all on the national level.

A foresight often contains results or other meaningful content that can be interpreted in different ways. It is therefore appropriate to test the robustness of the foresight's preliminary proposals for concrete efforts, initiatives or action plans. Such a robustness check can be done in several ways. The recommendations can be tested through scenarios or a SWOT analysis. The robustness check can be carried out by a broad circle of actors, which makes it possible to include a broad spectrum of viewpoints from the greatest possible number of stakeholders and actors. The robustness check can also be carried out by few selected actors, which would give more room for dialogue and discussion between steering group and actors.

Dissemination

The aim of this sub-phase is to disseminate and create ownership and root the foresight's results and recommendations among the foresight's target group and actors. Ultimately, this sub-phase is about the alignment of resources and relevant stakeholder groupings in relation to the action plan.

The informal dissemination of results occurs through the process's participants. The formal dissemination of results of the foresight takes place in two ways: first, through publications, which include formal reports, newspaper articles, press releases and other media-oriented material (for both printed and electronic media), TV and radio programmes, scientific articles etc. Second, dissemination can take place through meetings, such as press conferences, workshops, seminars, conferences etc. In both cases, dissemination should harmonize with each of the different target groups.

A foresight's result can often be translated into short-term or long-term strategies and plans of action. Road mapping can serve as a tool to develop and describe implementation of a foresight's results.

Although utilizing the foresight's results and recommendations is decisive for the foresight's success, it is usually unrealistic to take the concrete implementation or use of results into account in the foresight process itself. Use and implementation of results and recommendations can occur both directly and indirectly. Direct use usually requires that the foresight becomes part of a certain decision-making process with well-defined decision makers who have clearly expressed the wish for a foresight project. Indirect use is characterized by the foresight's perspectives and recommendations being used as the basis and inspiration for new agendas or being partly integrated in other project contexts.

Learning

After the conclusion of a foresight, experiences should be gathered in order to ensure that both the domain-specific and processual learning from the foresight process are systematically processed and described, so that they can benefit future projects.

The steering group, participants and target groups are primarily interested in the foresight's results, while the client and especially the project team have professional and future interests in a systematic summary of experiences from the process. Often, resources are not earmarked to describe experiences from the project; as a result, this silent knowledge largely remains with the individuals who have been involved and therefore disappears in connection with, for example, job changes.

The experiences collected can contain evaluation and monitoring of the foresight's effects in relation to the original goal. A very central subject would be to (re-)consider significant indicators that express the degree of goal fulfilment. Another subject would be how the effects can be monitored. A procedure for this could be to analyse how often and in what ways the foresight's results are referred to in reports, on homepages etc., but this would not be an appropriate measure for evaluating the effect. Often, part of the foresight's knowledge and learning is embedded as silent knowledge in the participants in the process, and it can be difficult to follow and measure the effect of such knowledge. Therefore, it is important to remember that it can take several years before the effects of a foresight process emerge, and that all the effects are probably impossible to monitor.

Methods for foresight

This section presents general characteristics of foresight methods, and more detailed descriptions of some selected methods that are judged to be especially relevant in a Danish context.

Characteristics of the methods

It is not a simple matter to categorize foresight methods, since they often integrate several method elements and are therefore overlapping. One approach is to structure foresight methods according to their type and knowledge sources (Popper, 2008a).

Method type can be determined with the help of three categories: qualitative methods, quantitative methods and semi-quantitative methods.

Qualitative methods can be used to investigate conditions that are difficult or impossible to measure or quantify. These methods make it possible to discuss and exchange viewpoints. Qualitative methods emphasise understanding phenomena or events based on empathy, analysis or interpretation of, for example, statements, evaluations, convictions or attitudes. The results can often be difficult to reproduce or verify. Examples of qualitative methods are simulation games (for example, war games), qualitative scenarios, back casting, SWOT analyses, brainstorming, relevance-tree analyses, future workshops, surveys, citizen panels, interviews, scanning, and literature reviews.

Quantitative methods emphasise gathering large amounts of 'hard' data, i.e. information that is directly measurable and can be quantified. Often, the use of quantitative methods implies that the investigator considers the area of study as an object that can be investigated in relation to one or more variables. The results are often expressed in numerical values, diagrams or graphs. Popper names three examples of quantitative methods: bibliometric analyses, extrapolation and modelling. Patent analyses, indicators and time series analyses can also be included in this method type.

Semi-quantative methods use mathematical (statistical) principles to manage and quantify rational judgements, probabilities, values and viewpoints of experts and commentators. Examples of semi-quantitative methods are quantitative scenarios, roadmapping, Delphi, key technology analyses, multicriteria analyses, stakeholder analyses and cross-impact analyses.

In addition, Popper notes that there are several methods that cannot be fitted into this typology: intuition or genius forecast, wild cards, science fiction, role playing, benchmarking and opinion polls.

Methods' sources of knowledge can be characterized in four dimensions: creativity, expertise, interaction and evidence. It must be stressed that the four sources are not mutually dependent and that most methods are based on a combination of all four knowledge sources.

Creativity is a combination of original and imaginative thinking and intuition. Artists, technological 'gurus', visionaries and great thinkers, or just ordinary citizens, contribute to foresight with this form of input.

Expertise is based, however, on persons' skills and knowledge within a special focus area or a specific issue. These persons can be researchers, consultants, leaders of enterprises or others with special knowledge in the relevant area.

Interaction is based on two considerations – first, recognition that experts and expertise are also to be found outside knowledge institutions and that their knowledge is both valuable and indispensible in foresight projects; and second, that new ideas and thinking have better chances of being generated when different types of experts and expertise are brought together in direct dialogue and can challenge and exchange each other's viewpoints.

Evidence recognises the importance of supporting projections and/or explanations of phenomena with analyses of reliable data and the use of well-documented methods.

The two dimensions, type of method and sources of knowledge, can be used to present a schematic overview of foresight methods. Figure 4, while not including all methods, shows some that Popper (2008a) considers the most important.

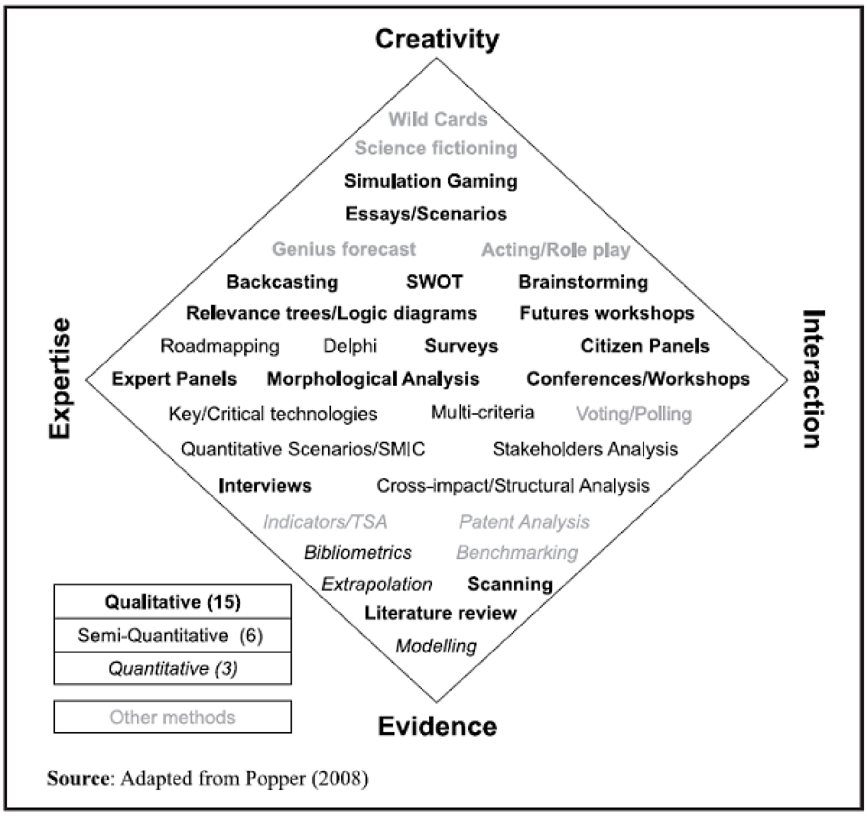


Figure 4. Methods for foresight categorized according to type and knowledge source (Source: Popper, 2008a).

Selected methods

In the following, selected foresight methods that are judged to be especially relevant in a Danish context are described.[6] One of the selected methods, megatrend analysis, is not included in Figure 4, but the method is included here, since it is sometimes an element in foresight projects.

Megatrend analysis

The term 'megatrend' is usually attributed to John Naisbitt's book *Megatrends* from 1982. Megatrend is often defined as large, important development tendencies on the national and international levels. Megatrends are furthermore characterized by being stable enough to continue their course in spite of shifting conditions in society; however, there is no generally accepted definition of megatrends.

[6] On the internet, many overviews and descriptions of foresight methods can be found. They often contain comprehensive literature lists for those who wish to study the methods further. The most complete is probably *Futures Research Methodology*, edited by J. C. Glenn and T. J. Gordon from AC/UNU Millennium Project. The book is found on CD-ROM and is regularly updated. Version 3.0 is 1300 pages: http://www.millennium-project.org/ millennium/FRM-V3.html#toc. Glenn and Gordon's work is the foundation for method descriptions in FOR-LEARN, which is a European knowledge-sharing platform for foresight: http://forlearn.jrc.ec.europa.eu/index.htm.

Like other methods in foresight research, analyses of megatrends are considered more art than science. It can be very difficult to substantiate that an identified trend is stable enough to form the basis for extrapolation with any reasonable degree of certainty. It can often be more fruitful to question what could happen if the assumed megatrend does not continue.

Megatrends can be projections of known development tendencies, i.e. historical footprints in time such as population growth, changed demographic composition or economic growth causing pressure on resources. Other megatrends that are more complex are concerned with development tendencies in the labour market, service or quality of life.

Some enterprises use trendspotters in connection with new products and new customers. And the German industrial giant, Siemens, has identified and used four megatrends in a general orientation of the firm's strategic development: demographic changes, urbanization, climate changes and globalization. Public authorities also use megatrends in connection with planning and regulation of sectors in society. Typical examples of such megatrends are: demographic changes (for example, ageing and the resulting need for care) and climate change (for example, heavier rainfall and the resulting adjustment of the sewage system). In foresight projects, megatrend analyses are often used with other methods. Megatrend analyses can be used to map and analyse the strategic surroundings for the foresight's focus area, and megatrends can be used as input to scenario or SWOT analyses. One procedure is presented in Box 3.

Box 3. Procedure for using megatrends in foresight.

1. Start with existing and described megatrends – for example, from World Future Society. Often, the same megatrends can be found several places.
2. Dissolve these megatrends into sub-trends or deduced consequences in relation to the foresight's focus area and context. Climate change can for example cause heavier rainfall in Denmark while it causes drought in Africa.
3. Evaluate each megatrend, sub-trend or deduced consequences in relation to the foresight's context and general goal. Here, it can be useful to define a set of evaluation criteria. Choose the megatrends or sub-trends that have the greatest significance for the focus area in question.
4. A list of significant megatrends can be used to initiate a foresight process, for example as the basis for scenarios or to define external threats and possibilities in SWOT analyses.

In the literature, very few methods are described for finding and verifying megatrends. Slaughter (1993) describes how Naisbitt found the megatrends described in his book, *Megatrends*. The sources were stories in American newspapers and other printed material. A team of analysts made some structured content analyses of this material. The analyses were collected and interpreted by Naisbitt himself. The result was, with Slaughter's words, "*...a fascinating, provocative and highly idiosyncratic overview of change processes*". Sultan et al. (2008) and Güemes-Castorena (2009), for example, present practical procedures for describing, verifying and interpreting megatrends.

Expert panels and expert papers

Including experts is a method that is widely used in foresight as a way of creating, qualifying, legitimizing and evaluating pictures of possible future paths of development.

Experts are often used when the relationship between concrete knowledge and intuition about future developments is uncertain. Emphasis is therefore put on reflexive processes in which the experts' evaluations are presented openly and commented on by other experts or laypersons, so that the experts are confronted with their own and other's statements. Experts can have different functions in foresight exercises. First, experts can summarize and present existing knowledge in systematic ways; and second, experts can create new knowledge in the form of visions and ideas or, on the basis of their common knowledge, point to new possibilities and new networks. Furthermore, experts often make informal contributions or carry out functions such as dissemination of results and direct contributions to follow-up activities.

The selection of experts can be made as a co-nomination process (Nedeva et al., 1996). This is a rolling process in which experts are asked to choose a number of subjects and trends that are of interest in a given area, and then to nominate additional experts within these subjects and trends. Stakeholder analyses and descriptions of the foresight's focus area can also serve as instruments for selecting experts.

Expert panels are one of the most used methods for including expert knowledge in foresight processes. The expert panel can function for the whole foresight process, or it can contribute to a narrowly defined sub-process. The panel has typically 8-20 experts who are often selected on the basis of four criteria: variety in professional expertise, variety in experience, variety in actor types (institutional affiliation), and finally variety in personal characteristics such as gender, age or ethnicity. If the panel's work is primarily focused on creative and long-range perspectives, both professional knowledge and personal competences are important. An experienced facilitator and strongly structured meetings are crucial to the usefulness of expert panels.

If these qualities are not present, it can end with unstructured discussions or just exchanged viewpoints. Another important observation is that it cannot be expected that unsalaried members of expert panels work between meetings. Here, the most that can be asked is that they prepare themselves by studying five to ten pages of written material. This puts further focus on the need for effective panel meetings, since most of the expert panel's work is carried out during these meetings.

Box 4. Expert paper for a research area of national interest.

1. Introduction. General introduction, authors, contributing experts, general sources etc.
2. Description of the research area. Limitation and definition of the actual research area.
3. Categorization of research themes within the area. List with key words describing the most important national and international research communities.
4. Future applications and business opportunities. Presentation of different paths of development, since these differences can have great influence on evaluating future possibilities.
5. National positions of strength. Evaluating national positions of strength seen in an international perspective, eventually supplemented by a list with brief descriptions of domestic or national enterprises and research communities as well as the most important international ones.
6. Research and innovation needs. List of the most important research needs and problems within the foresight's time horizon.

An expert paper is an inexpensive and effective way of including experts' knowledge in foresight processes. Expert papers can comprise a description of the state and development perspectives of a technology area, research area, strategic challenge etc. See Box 4. The authors are responsible for the content of the paper. An expert paper should preferably be focused and present a coherent argumentation. Expert papers are often 20-25 A4 pages in length. Expert papers can be written by a single expert or an expert group. The paper can be quality controlled by being supplemented or challenged with brief written comments by other experts. Another possibility is to submit a paper to open hearing or comments.

The term 'expert' is rather unclear however. It is also often unclear who and what determines whether someone can be called expert. Furthermore, expert evaluations are often two-faced – on the one side, expert evaluations are very much in demand; and on the other hand, they are often received with reserve and distrust (Loveridge, 2004). Common for expert evaluations is the uncertain relationship between concrete knowledge and intuition, especially where the future is concerned. Experts, like other people, have subjective opinions, personal judgements and preferences, which are all a source of uncertainty (Loveridge, 2004). Furthermore, it has been demonstrated many times that experts have a tendency to be too optimistic with respect to their own knowledge and development possibilities within their own area, as well as a tendency to underestimate how difficult it is to realise ideas and potentials (Tichy, 2004). For example, leading researchers in a technological area are not necessarily also experts in product development, market potential, political decision-making processes or means.

Citizen panels, public hearings, consensus conferences etc.

Some methods aim to ensure participation in foresight by the general public. International experiences indicate that inclusion of the general public in dialogues and decision-making processes is important for achieving socially robust solutions in connection with implementation of new technology (Gibbons, 1999). Broad inclusion of the public can occur during at least three situations in foresight processes:

- during the execution phase's collection of subjects and themes
- during the prioritizing phase's choice of criteria
- as more or less passive recipients of the results.

Public contributions to the execution phase's collection of subjects, tendencies and opportunities are not likely to produce significantly different input than contributions using other methods. The consideration here is primarily for the process's openness and broad dialogue. However, public inclusion in the prioritizing phase can lead to contributions that are significantly different from those of the experts. This applies to the discussion of specific themes' importance for society and for the individual, also regarding relevance criteria and possible priorities. Especially in connection with socially and politically controversial subjects it is useful to include viewpoints from the public at large.

Public participation can be achieved in many ways. In Denmark, methods where people meet physically have had positive results: citizen panels, public hearings, consensus conferences, focus groups etc. This is because these situations provide good possibilities to ensure the quality of the contribution. It is possible to ensure the composition and representivity of the panel, the quality of individual participants' contributions, and dialogue between the public and experts. In contrast, experiences with internet hearings are mixed. Completely open internet hearings can be difficult with respect to ensuring contributions of sufficiently high quality. Finally, telephone interviews, opinion polls or other structured methods can be used to collect the public's views.

SWOT analysis

SWOT stands for Strengths, Weaknesses, Opportunities and Threats. The aim of SWOT analysis is to evaluate a given organization's (technology area, branch or focus area in the broad sense) position with regard to competition or strength through a simple analysis of, on the one hand, its internal strengths and weaknesses, and on the other hand, the external opportunities and threats. Strengths and weaknesses can be understood as the factors the organization can influence, while opportunities and threats are factors that the organization cannot influence. Megatrend analysis can eventually be used to determine external factors.

SWOT analyses can be used in at least two ways in foresight processes. SWOT analyses can be used early in the foresight process to find the foresight's focus area, and can also be used late in the process to formulate and evaluate criteria for focusing and prioritizing.

Time and resource use for SWOT analyses is quite elastic and depends on the level of ambition. Commonly used strategy textbooks often include a more detailed description of the method and its use.

Delphi method

The Delphi method was developed in the 1950s by Ted Gordon, Olaf Helmer and Norman Dal – key members of the American institution, Rand Corporation – in cooperation with the US Air Force. The aim is to include and structure expert knowledge in an iterative process that exploits creativity through group brainstorming, while seeking to avoid inappropriate psychological and behaviouristic effects in groups.

In connection with foresight, the aim of the Delphi method is to create consensus or clarify disagreements among experts regarding the time horizon for future developments, economic or social effects of developments, or the means to promote developments. Since the method can be used so that the participants are anonymous, it has been widely used in contexts and cultures where it is not natural to express disagreement with colleagues and authorities. The Delphi method can be combined with other methods: expert panels, co-nomination, mapping, scanning, trend analyses, scenarios etc.

The Delphi method has three main elements. The first element is formulation of a series of statements (or hypotheses), for example about scientific and business opportunities for future development and use within a given area (see Box 5). Formulation of the statements should be carried out by experts in the given area in a structured iterative process that ensures that the foresight's focus area is sufficiently covered. Studies show that statements should be formulated in up to 20-25 words. Experience also shows that the reply percent decreases, if the same respondents are presented with more than 40-50 statements in the same investigation.

The second element is a series of questions that can be asked in relation to the statement. The questions relate, for example, to: a) how the statement can be realized; b) relevance in relation to the foresight's goal (potential economic significance, news value, the country's position of strength etc.); c) the means that promote or the conditions that inhibit realisation of the statement (research, cooperation, market creation, international standards). Formulation of the questions must be in close agreement with the whole foresight project's goal. Both statements and questions should be unambiguous and the answer choices should allow both agreement and disagreement among the experts.

Box 5. Formulation of a Delphi statement.

Example of formulation of the Delphi statement:
Direct methanol fuel cells (DMFC) as power source for more than 50% of all new mobile phones and laptops.

To promote understanding and avoid ambiguity, the statements often comprise certain semantic parts:
- One part indicates the technology area: power source.
- A second part relates to the knowledge area: direct methanol fuel cells.
- A third part expresses precisely the area of use or market niche: power source for mobile phones and laptops.
- A fourth part indicates the technologies or the market's development level: more than 50% of all new.

Some of the large Japanese, German and English Delphi studies use some qualitative standard expression for development levels: elucidation, development, first practical use, widespread use. It is recommended, however, to use more quantitative expressions.

The third element comprises iterations with inclusion of the involved experts, both to formulate and structure the statements and answers to the questions. In answering, participants can be anonymous. The answers are made (ideally) in at least two rounds, where the result of the first round is accessible when answering the second round. Ideally, the process should make it possible to explain and re-evaluate the participant's own answers in the light of the result of the first round. Figure 5 shows an example of a Delphi form used in the project, Nordic Hydrogen Energy Foresight.

		Your level of expertise on the field of the statement Only one tick			Period in which the statement will first occur Only one tick						Region leading market development today One or more ticks						Most important actor over the next 10 years to promote the statement One or more ticks					Policy measures over the next 5 years to promote the statement One or more ticks					
Statement No.	Statements about future hydrogen and fuel cell technologies	Own field of expertise	Knowledgeable	No knowledge	Before 2010	2011-20	2021-2030	2031-2050	After 2050	Never	Nordic countries	EU	USA	Japan	Other regions	Do not know	Research institutions	Equipment industry	Energy providers /utilities	Governments	Others	Rising public awareness	Support R&D	Support demonstration	Stimulate early markets	Taxes & regulation	Codes and standards
	Production and Transmission																										
1	Hydrogen used as an energy carrier constitutes 5% of the global energy system	○	○	○	○	○	○	○	○	○	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
2	Hydrogen used as an energy carrier constitutes 20% of the global energy system	○	○	○	○	○	○	○	○	○	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
3	Methanol (or similar hydrogen rich fuels) from renewable sources win over hydrogen as energy carrier in the global energy system	○	○	○	○	○	○	○	○	○	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
4	Renewable energy surpasses coal, natural gas and nuclear as primary source for hydrogen	○	○	○	○	○	○	○	○	○	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
5	First shipment of liquid hydrogen produced by renewable energy in a remote place (i.e., desert or artic area)	○	○	○	○	○	○	○	○	○	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
6	First dedicated hydrogen pipeline from natural gas field to major energy market	○	○	○	○	○	○	○	○	○	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
7	First large-scale storage (>100 MW) of hydrogen is established as energy buffer for fluctuating energy sources (i.e., wind energy.)	○	○	○	○	○	○	○	○	○	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
8	Storage losses per day of pressurised hydrogen are reduced to 10% compared to the 2004 level	○	○	○	○	○	○	○	○	○	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□

Figure 5. Example of a Delphi form to be filled out by expert groups. This can be done with internet-based survey tools or on paper – for example during focus group meetings. The form is the first part of a Delphi questionnaire used in the project, Nordic Hydrogen Energy Foresight.

The Delphi method is semi-quantitative in the sense that the answers are statistically processed. One of the method's strengths is that the main results can often be presented graphically in tables and graphs. Another strength is the results' legitimacy, in that the scope, criteria and processes are transparent. The weaknesses of the Delphi method are that the method is very demanding in time and resources, and that the results are extensive and can be difficult to communicate in detail. The method is criticized for presenting a picture that is focused too much on technology, is too optimistic about the future, and is too superficial in relation to more complicated cause and effect relationships. Finally, the method is criticized for drawing a picture of future development that reflects to a greater degree the ideas and conceptions of the time in which the investigation is being conducted, rather than the real future development.

Future workshop

The future workshop emerged at the end of the 1980s, and was developed by the researcher Robert Jungk (Jungk and Müllert, 1984). The theory and intention is that imagination must be set free to the greatest extent possible in a thinking and idea workshop.

Future workshops' principles are participant steering and action orientation, and it is suitable for creating dialogue directed toward joint future actions. The basic conception is that it is the participants' own experiences and competences that should be brought into play. The aim is to formulate concrete proposals for actions and solutions that the participants themselves can implement. The future workshop is especially suited for working with local issues, and the aim is usually to make solution proposals to meet local challenges or to plan local initiatives meant to promote a desired development.

At the future workshop, work is carried out in a three-phase process:

- Criticism phase: Criticism of the present situation is formulated. It is written down, and the most important points of criticism are selected and translated into critical themes.

- Vision phase: A brainstorm is held on the basis of the criticism formulated in the first phase. Proposals and ideas are drawn up as a draft for a proposal for action, and this draft is divided into themes.

- Realisation phase: A critical trial is made of the draft for a plan of action; possibilities for realisation are evaluated, and the action proposals are developed further into more concrete steps toward realisation of an action or project.

A future workshop can last for a few hours or several days. The usual duration is a single day; the morning is used for the criticism phase, the first part of the afternoon for the vision phase, and the last part of the afternoon for the realisation phase.

Scenarios

The scenario method is often ascribed to Herman Kahn from Rand Corporation, who in the 1950s and 1960s developed the method to analyse alternative possibilities in connection with the cold war between USA and the Soviet Union. At the end of the 1960s and the start of the 1970s, Shell Oil successfully used scenarios to develop their strategy, and the firm thus stood better prepared than its competitors for the large oil price increases in the 1970s.

Scenarios are systematized visions regarding an organization's or a focus area's future surroundings and development opportunities. Scenarios are developed over different outcomes of development tendencies that can be expected to influence the actual issue. Scenarios can be quantitative and based on model calculations and extrapolations of past developments. Scenarios can also be qualitative and consist of stories or essays that describe different but plausible futures. A scenario is thus neither prediction nor prophesy. A scenario describes a series of events in order to demonstrate development opportunities and consequences.

Scenarios are characterized by:

- focusing on elements in the future that are unforeseeable (or difficult to foresee)
- structuring presently existing knowledge in a systematic way
- identifying plausible alternative futures
- ability to contain discontinuities
- ability to be both qualitative and quantitative.

The scenario method is an operational instrument for decision-making in uncertain and complex situations. The use of scenarios in connection with strategic planning has won great acceptance in recent decades. An important explanation is that enterprises' and organizations' surroundings are becoming increasingly complex; therefore, traditional planning instruments are no longer considered sufficient. The aim of using scenarios in planning is to create dialogue and increase decision-makers' understanding of future opportunities and the surroundings' dynamics: "*... ultimately, the end result of scenario planning is not a more accurate picture of tomorrow, but better decisions today*" (Schwartz, 1998).

Three main groups of scenarios are found (see Figure 6).

Predictive scenarios aim to describe the most plausible future, based on continuation of present trends and contexts. One version of this type of scenario is basically an extrapolation, often termed a 'business-as-usual' scenario, because it does not try to describe unexpected surprises, radical innovations or other marked shifts. Examples of predictive scenarios are the different energy scenarios from the International Energy Agency, or the various climate scenarios. Scenarios serving as alternatives to 'business as usual' can be introduced by assuming marked changes or shifts in the prerequisites (for example, new large oil sources, changed toll systems or changed consumption patterns), and then calculate their effects.

Explorative scenarios have the aim to unfold and explore a series of equally plausible future developments.

This is often a far more qualitative approach, where emphasis is on specific driving factors in realising possible future developments. Explorative scenarios can be used in two ways. Either strategic choices can be evaluated and judged in the light of these equally plausible scenarios, or strategic choices can be made in the light of these scenarios. This type of scenario is probably most used in foresight exercises.

Anticipative or normative scenarios aim to create consensus around a common vision and, on this basis, formulate choices and priorities for realising the vision. This process is also called 'back-casting', since planning is made backwards from the desired end stage to the present. Political visions such as "Peace in the Middle East" or "Covering Denmark's energy consumption with renewable energy" can be considered normative scenarios.

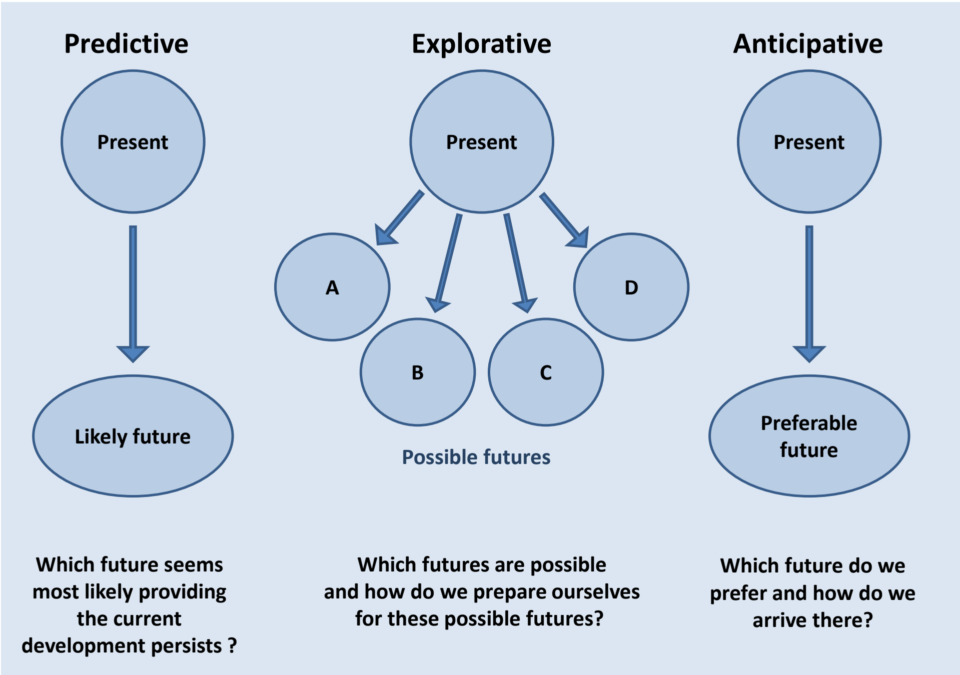


Figure 6. Three main groups of scenarios.

Scenarios can be used in foresight processes in three ways. First, the scenario process itself can be used to challenge 'mental models' and/or to create a common understanding of a focus area's development possibilities (for example, a technology) among actors. Second, scenarios can be used to test or check the robustness of existing strategies in relation to possible events in the future. Finally, scenario processes can be used to formulate common visions and strategies for a focus area.

In the following, the process for explorative scenarios, often called the GBN (Global Business Network) model is described. The central element here is to point out, evaluate and prioritize the most important challenges, driving factors and development tendencies. Here can STEP analyses structure the first collection of tendencies.

Individual driving factors with related causes and effects can eventually be clustered together. To assist prioritization can the driving factors be placed in a matrix with four quadrants as illustrated in Figure 7.

The two main parameters for structuring the driving factors are the driving factor's importancy and uncertainty in relation to the impact on the development. In the matrix, it is the driving factors' relative placement that is important. Structuring and selecting driving factors are often carried out as a group process, and statements and comments about the driving factors' placement in the matrix are noted for later use. A

STEP analysis can be used to assist the search for driving factors.

After this, the driving factors' dynamic is discussed and evaluated, and on this basis, a selection is made of the most significant driving factors. The factors with low importance are eliminated. Factors with high importance and low uncertainty are termed 'trends', i.e. factors that to a certain extent apply in all cases. Factors with high importance and high uncertainty are termed 'key uncertainties', and these form the basis for the rest of the scenario process. Factors with high potential importance and very high uncertainty are sometimes termed 'wild cards'.

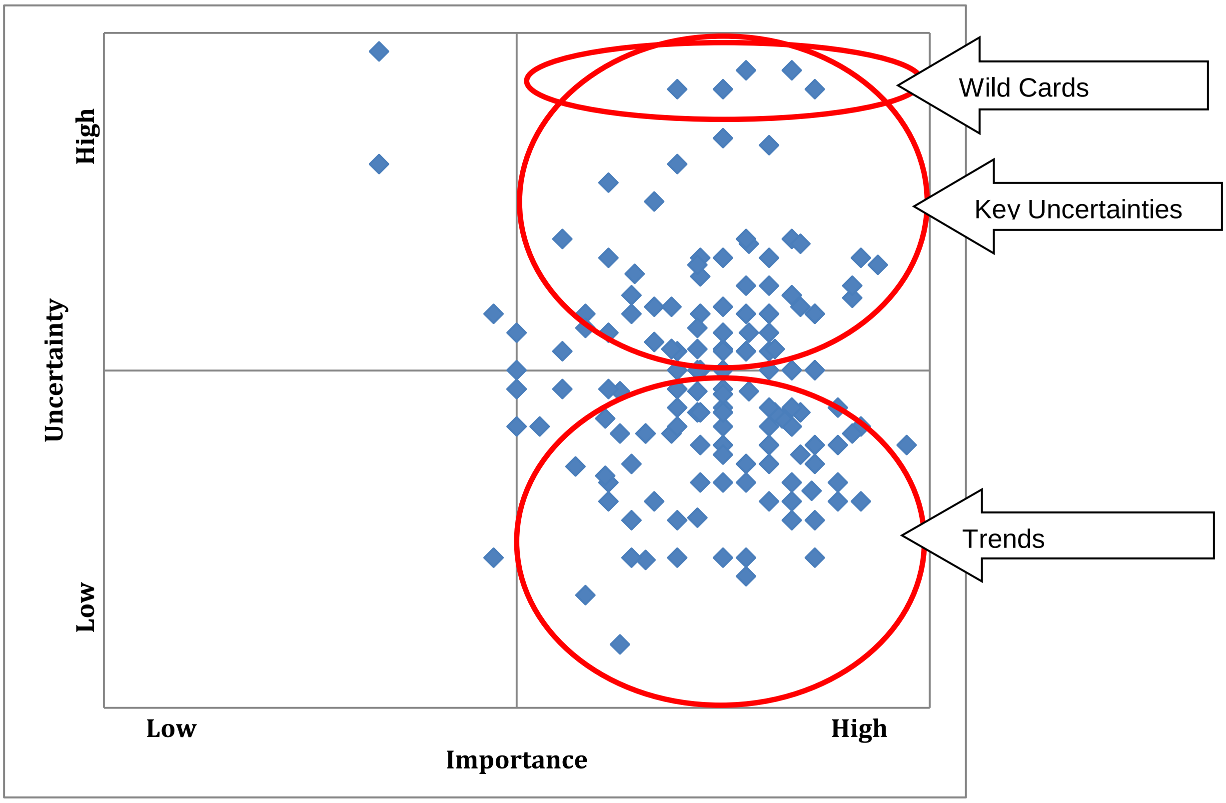


Figure 7. Example of placement of driving factors according to importance and uncertainty. Placement here was arrived at through an expert evaluation using a questionnaire.

Key uncertainties and maybe wild cards form the basis for the construction of a so-called scenario-cross (see Figure 8). Usually, the two most relevant driving-factor clusters are selected, where the combinations form the basis for four scenarios. Note that the foreseeable factors/events/trends should influence all four scenarios. Finally, the four scenarios are described. This is often done in a series of essays on possible future developments. The important thing is that the completed scenarios are plausible, i.e. that the described events really could take place. Furthermore, each scenario describes the consequences for the involved organization. It is a good idea to name or title the four scenarios so that it is easy to remember them. The names should also express an interesting coherent picture of a development path dominated by the selected significant driving factors.

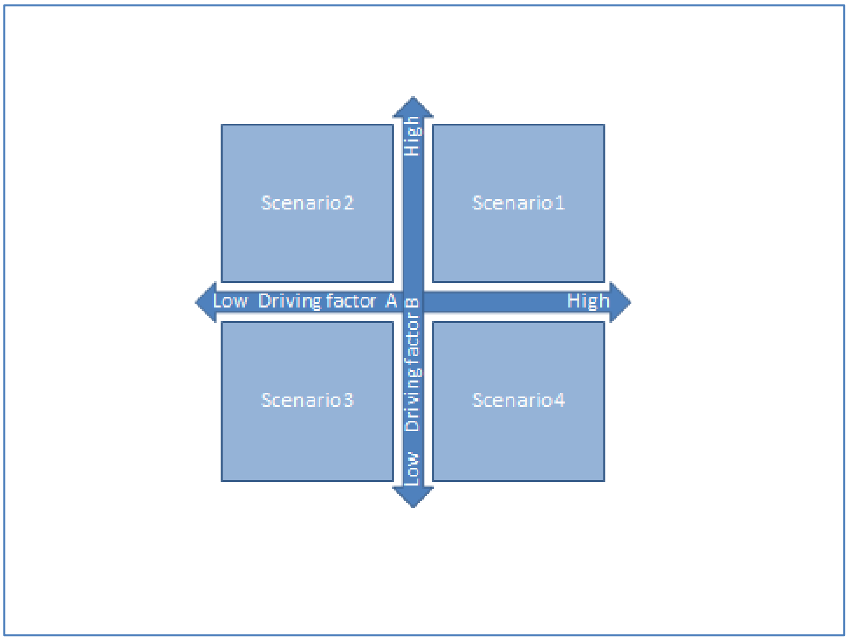


Figure 8. Scenario-cross.

Roadmapping

Roadmapping has its roots in technology planning in the American automobile industry and in the 1970s was further developed by firms such as Motorola and Corning (Phaal et al. 2004). As the name indicates, roadmapping is a process for defining and making possible paths toward a specific goal visible. The graphic presentation is an important element in the process. In this sense, roadmaps are similar to PERT and Gantt diagrams, known from project planning. Roadmaps are used as decision-making tools, but can also contribute to creating consensus, clarity and a form of forward-looking perspective for a desired development.

Many variants of roadmapping and its uses exist however. On the enterprise level, roadmapping is often used as a tool to plan production development. In the process, the connections between a desired goal (introduction of a new product to the market), the product's properties, the necessary technological development and development of the means of production, the supplier network, research etc. are identified and made visible. On the branch and business sector level, roadmapping is used to coordinate the mutually competing firms' common interest in strategic research and technological and competence development, as well as market development. Roadmapping can also be used in completely different contexts. For example, a quartet consisting of USA, EU, Russia and UN made a 'Roadmap for Peace' for the peace process between Israel and Palestine. In the following, the focus is however on expert-based research and technology roadmaps.

Figure 9 shows a schematic example of a roadmap. The roadmap and roadmapping here have four dimensions. The first dimension is the horizontal axis, the time aspect of the process that is being planned. On the left side is the present and in some cases historical prerequisites for the future development. On the right side is the future vision or the goal that should be realised. The second dimension is the vertical axis, which has different layers. The top-most layer relates to the goal of the roadmap activity. If this concerns product development in an enterprise, this layer will contain questions concerning the enterprise's goals and its strategic surroundings. The lowest layer relates to the resources the enterprise can use to achieve the formulated goals. Such resources can be technology and competences, and also financial resources, partnerships, production facilities etc. Most important, however, is the middle layer, which relates to the use of the resources to achieve the goals, for example through development of new products, new services or new processes. The third dimension relates to the future developments, results, events or activities that are necessary in order to achieve the given goals, and link them in a temporal sequence. This is often done graphically in the form of boxes in each layer and arrows that connect each of the boxes.

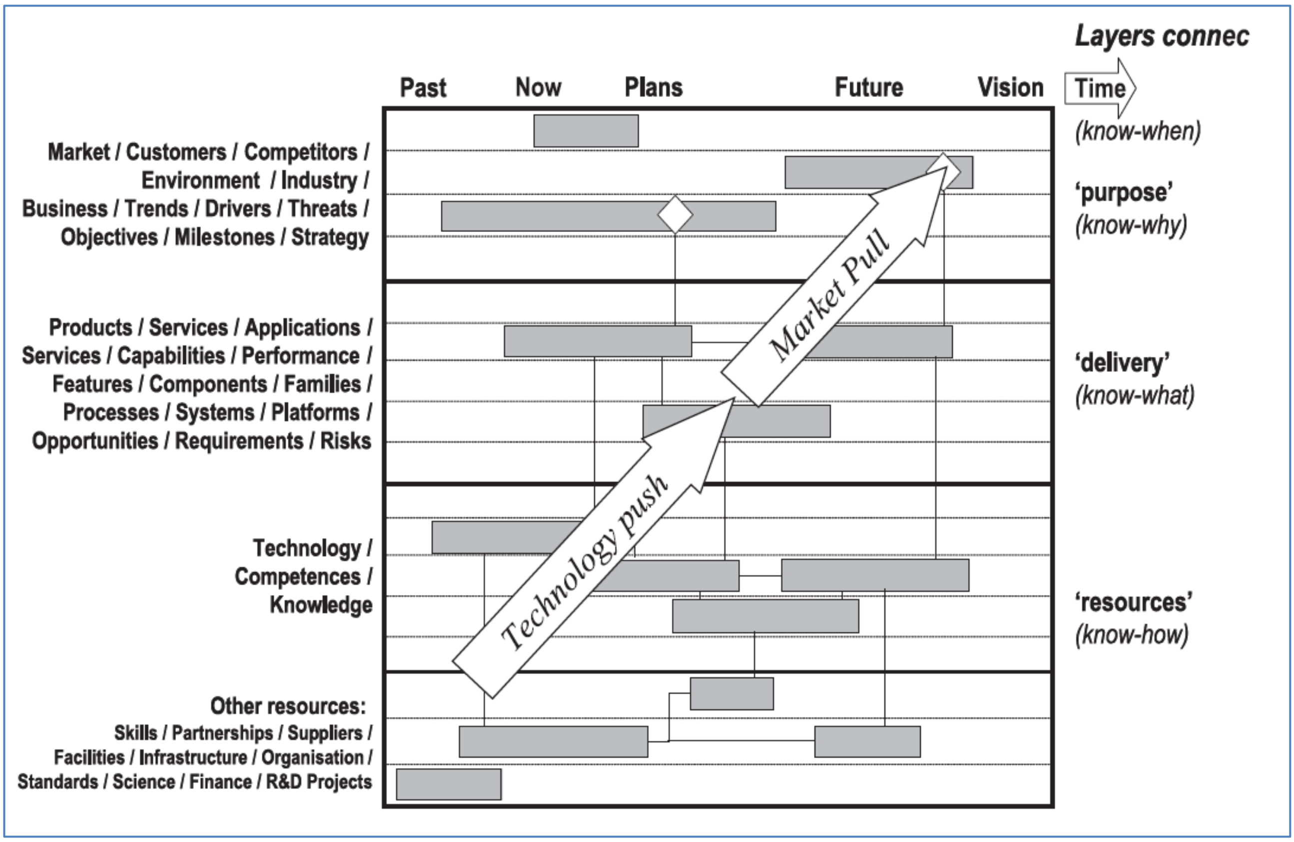


Figure 9. Schematic example of a roadmap. (Phaal et al., 2004).

The fourth dimension is the (roadmapping) process itself, through which the result (the roadmap) is created. The process can comprise four phases, each of which relates to one of the three layers plus the final sequence. Roadmapping is often a participative process, and expert-based roadmap processes are often very demanding in resources. Roadmapping is thus a complex process that uses other methods, such as visions and scenarios, SWOT analyses, extrapolation of development tendencies, expert panels and consequence evaluations.

Extrapolation and quantitative trend analyses

Trend analyses include a broad range of quantitative methods based on extrapolation of historical data. Trend analyses are based on the following assumptions:

- The future is an extension of the immediate past, because human behaviour follows certain laws that can be expressed quantitatively.
- The future is foreseeable, if the underlying laws and causal relationships are known.

The simplest form of projection is a linear extrapolation of an historical development. The weakness of extrapolations is of course that they cannot say anything about shifts in technologies or in market conditions.

Instead of simple linear extrapolation of an historical development, a model can be used that contains assumptions about how the development will happen.

Trend analyses or projections can be made with the help of S-curves or “Utterback curves”, which are based on the assumption that technologies usually have a certain life cycle on the market (Utterback, 1996). The S-curve hypothesis is that market growth is slow following the period after introduction to the market. After this period comes a phase of marked increase in sales. When the technology or product is mature, growth in sales decreases and can finally stop completely. Subsequently, new technologies that fulfil the same needs in a better way take over the market. An example can be spool tape recorders, which were replaced by cassette tape recorders and then by CD-ROM systems etc. S-curves are a simple model that often provides a useful description of new technologies’ market introduction and life cycle.

Another simple tool is the learning curve, which basically assumes that production costs are reduced by a certain factor, typically 5-15% each time the accumulated production (the total number of products since introduction to the market) of a product is doubled (see the example in Figure 10). Learning curves are often presented however as the opposite – as Progress Ratio (PR). Learning curves were first described by Wright for American aircraft production back in the 1930s. In the 1960s, the consultant firm Boston Consulting Group developed the concept further (BCG, 1972). Learning curves have traditionally been used in production firms with high piece rates. In industrial contexts, learning curves can contribute to setting goals for future cost development. The International Energy Agency under OECD has come far in using learning curves to make priorities between different energy technologies on the basis of their future properties. Therefore, the energy sector is one of the sectors in which learning curves are perhaps most used at present. Learning curves are for example included in large simulation models for future energy systems. Experience shows, however, that the strength of learning curve analyses probably lies more in the overview and the changed ‘mental models’ for technological development that the analyses provide rather than in the analyses’ ability to predict development. The simple projections are often based on uncertain and incomplete historical data that make precise projections difficult.

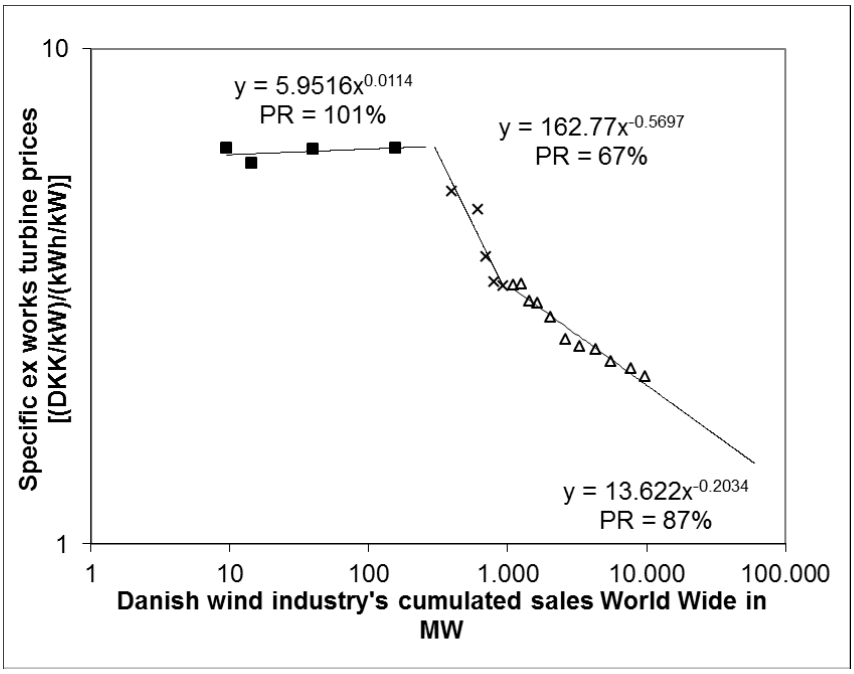
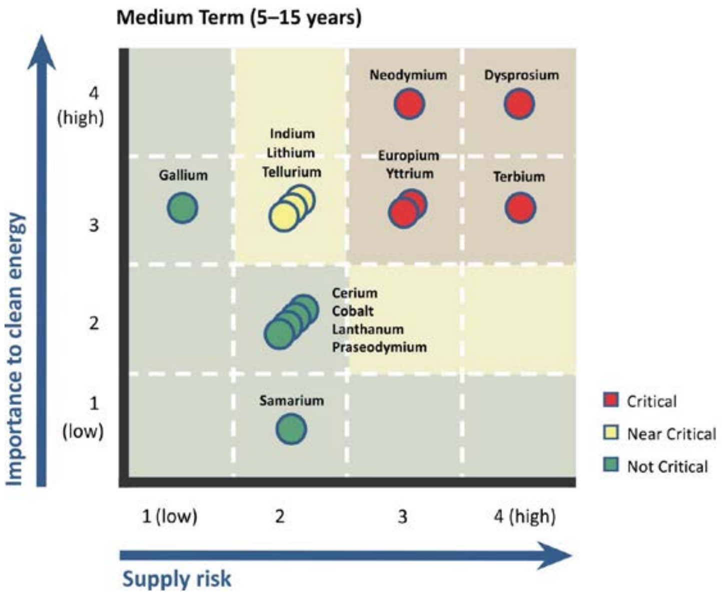


Figure 10. Example of a learning curve. On the x-axis are the Danish turbine industry’s cumulated global sales in MegaWatts during the period 1981-2000. On the y-axis is a so-called specific ex works prices (i.e. the turbine price ex works adjusted with its capacity to produce energy under standardized conditions). Extrapolation must be made with great caution. Source: Neij, Dannemand Andersen and Durstewitz, 2004.

Critical technologies lists

Analyses of critical technologies lists are used to determine the technologies or knowledge areas that are especially significant for the actual focus area, i.e. a specific industrial sector, country or region, or in connection with certain public areas of responsibility or strategic challenges for society.

The concept of critical technologies (or key technologies) lists probably has its roots in countries' strategic interests in connection with access to critical raw materials. Historically, this has been foodstuffs, coal, steel and oil. Today, the focus is on such raw materials as rare earth elements. See Box 6. In some parts of the world, water is a strategic material. Since the 1920s, the US Congress has required that the country, in order to be prepared for unexpected military conflicts, should have strategic stockpiles of certain critical materials that have to be imported. Since then, the concept has spread to technologies that are similarly critical for the US defence and for the general industrial and economic development in the USA and many other countries.[7]



In 2010, the US Department of Energy investigated which rare earth elements were critical for new clean energy technologies. Among the main conclusions were that technologies such as windmills, electric cars, photocells and LED, both in the short term (0-5 years) and especially in the long and medium-long term (5-15 years) will face supply risks for all or some of these materials. For example, neodymium and dysprosium for permanent magnets are used in wind turbines and electric cars. Prioritizing criteria is here partly the rare earth elements importance for new sustainable energy technologies and partly supply security. Source: US DOE, 2010.

Box 6. Example of critical materials for renewable energy technologies in the medium-long term.

Lists of critical technologies lists can be used to make priorities for technological development and strategic research. National exercises regarding critical technologies are carried out especially in large countries like USA, China and France. In 2005, EU made a comprehensive description of key technologies: "Key Technologies in Europe".[8] Also in several industrial sectors critical technologies lists have been developed. This applies for example to the ICT sector and the energy sector. National processes regarding critical technologies can be quite costly and require the participation of many actors and experts. The time horizon for analyses of critical technologies is typically short: 3-10 years.

The basic elements of the method are variations and combinations of other foresight methods. The first element is a gross list of technologies that are important for the future development of the actual focus area. The gross list can consist for example in expert notates, interviews, expert panels, literature studies, patent analyses and bibliometric analyses. The second element is priority or relevance criteria for choosing the most important technologies. The third element is selection of the most important technologies with the help of these criteria. Expert panels carry out the tasks of making lists, selecting criteria and choosing the most important technologies; however, a steering group or its like can select the criteria on the basis of the

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7 http://clinton1.nara.gov/White_House/EOP/OSTP/CTIformatted/AppA/appa.html

8 http://cordis.europa.eu/foresight/key-tech.htm

foresight’s goal.

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This text is intended as a note for the PhD course, Strategic Foresight in Engineering. The text has three parts: First, as foresight is a quite ambiguously defined and understood entity, we shortly present our understanding of what foresight is. The second part is an introduction to foresight processes in practice. Finally, the text presents a few selected foresight methods that are commonly used in Denmark.

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ISBN : 978-87-93130-18-0