Technology foresight in the Nordic countries

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Publication date:
2002

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

Risø-R-1362(EN)

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Abstract In the globalised knowledge economy, with increased industrial and economic competition, intense pressure is put on companies to be adaptable and innovative. Private and public decision-makers must cope with rapid technological developments by anticipating new opportunities and threats. This has intensified the search for proper tools that will create strategic intelligence in decision-making systems. In this context technology foresight exercises are regarded effective tools for "wiring up" the innovation system.

Nordic technology foresight (TF) is defined as "systematic, future-oriented interaction processes contributing to shared visions concerning long-term technological developments. In the TF exercises, technological developments are examined in their real-world, economic and societal context, with attention to a wide pool of knowledge and the viewpoints of various interest groups. The processes can be broad-scope or more focused. The purpose is to facilitate communication between the interest groups and to increase decision-makers' and key actors' knowledge base, so that desirable technological developments can be supported with relevant Nordic strategies, decisions and actions. Both analyses and interaction are important in this respect".

The Nordic countries have a long tradition of cooperation within research, education, and innovation. Although the Nordic Council of Ministers aims at "developing Nordic region in next 10 years as the most attractive region in terms of education, research and industry", there seem to be no effective mechanisms capable of embracing the various activities and initiatives at Nordic level. Here a Nordic technology foresight may be a promising tool in building a Nordic knowledge region. By increasing Nordic competence and competitiveness, and by creating critical mass behind specific proposals, a Nordic TF may act as a gear change between national research and development activities and the larger European research system within Nordic priority areas.

In the Nordic countries governmental institutions, academia and private institutions have embarked on technology foresight activities, though with varying degrees of intensity and at different speeds. The rationale for Nordic technology foresight activities rests on the common values created through a common history and culture and a well consolidated Nordic collaboration within research and innovation. The potentials of a Nordic technology foresight are closely connected with spatial proximity and shared values, as well as with a willingness to exchange experience and to learn from each other. On the other hand, some doubtful concerns stem from the economic and social differences among the Nordic countries. Nordic foresight cooperation may also remain as a distant academic exercise if proper links to political and economic decisions cannot be made and maintained. A technology foresight exercise might serve different institutions of the innovation system and the society at large at the same time.

The report recommends:

1. The establishment of a Nordic forum for technology foresight practitioners and researchers.
2. The creation of a common follow-up system for relevant international technology foresight exercises (including monitoring of selected trends and early signals).
3. The realisation of technology foresight exercises that involve participants from various Nordic countries (e.g. focusing on specific technologies or problem areas or in selected cross-border regions).

ISBN 87-550-3109-9
ISBN 87-550-3110-2 (Internet)
ISSN 0106-2840

Print: Pitney Bowes Management Services Denmark A/S, 2002

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Preface

This project is co-financed by the Nordic Industrial Fund's *center for innovation and commercial development*, which operates under the auspices of the Nordic Council of Ministers. The Fund initiates and finances research and development projects and activities that create synergy between the actors in the Nordic innovation system. The project aims to contribute to the competitiveness of the Nordic business sector and to facilitate sustainable development through the creation of a Nordic knowledge market.

The project is a feasibility study. It ran during the second half of 2001 and the first half of 2002. Its purpose was to investigate the prospects for technology foresight activities in the Nordic countries and it was conducted by VTT Technology Studies in Finland and Risø National Laboratory in Denmark.

1 Introduction

Technology foresight studies and exercises (TF) are increasingly used by governments, funding agencies, research and development institutions and private companies as a tool for strategy development, the prioritisation of research and development funds, and learning. Attempts have been made to embark on technology foresight activities in the Nordic countries, but so far — with neither a common knowledge pool nor coordination behind them — these attempts have enjoyed only limited success.

This report offers a state-of-the-art description of technology foresight activities in the Nordic countries. It investigates the potential of common technology foresight activities to strengthen an integrated Nordic knowledge region. The report focuses on the foresight activities of, and scope for cooperation within, five North-European countries: Denmark, Finland, Iceland, Norway and Sweden. Some attention is paid to the potential for cooperation with other, nearby areas, especially the Baltic and arctic regions.

The findings of the report are based on a desk study of existing materials and consultation of selected experts within industrial development, research and regional development, including a fact-finding mission to Iceland in December 2001.

In outline, the report runs as follows:

- Introduction to technology foresight and definitions.
- The Nordic countries as a common knowledge region.
- Technology foresight activities in the Nordic countries.
- Expectations relating to Nordic technology foresight activities.
- Conclusion and recommendations.

2 Technology foresight: an overview

Economic globalisation has led to increased industrial and economic competition. Intense pressure is now placed on companies to be adaptable, innovative and fast. Rapid technological developments and the anticipation of new opportunities and threats have also intensified the search for suitable tools to face these challenges. As a consequence, technology foresight has received growing attention in various national and international forums. The discussion has been particularly lively at European level, where foresight processes are seen as important tools for developing competitive and sustainable strategies for an integrated Europe. Even the regional dimension has been emphasised in the European discussion.

A summary of recent research and discussion of technology foresight and nearby fields is presented below. The role of technology foresight as a tool for supporting innovation systems and strategic intelligence is briefly discussed. An examination of the stated objectives of technology foresight exercises then follows. After this, foresight methods and practices are reviewed, with particular attention to development paths and recent typologies.

The various lines of research are finally synthesised with the help of a model that describes the process of shared knowledge creation in foresight exercises, together with the role of formal tools and practices. Conclusions about the Nordic context are presented in the end of the chapter.

2.1 Improving strategic intelligence in innovation systems

With increased industrial and economic competition, companies are under intense pressure to be adaptable, innovative and fast. Science and technology are in complex interaction with the economy and society, and characteristically an increasing number of decision-makers are involved in innovation processes (Smits, 2002). In addition to direct interaction, indirect and diffuse ties that are not always easy to comprehend also exist. With accelerating technological developments and exponential growth of knowledge there is an urgent need for communication, networking and cooperation among producers and users of science and technology in the innovation system. As decision-makers cannot wait until the effects of technology are evident, the quality of decisions depends on 'strategic intelligence' (Tübke et al, 2001).

Innovation theories and empirical studies of the innovation process provide useful insights into the dynamics of innovation systems. In particular, the concept of a national innovation system describes the entire network of institutions in the public and private sectors and highlights how activities and interactions initiate, import, modify and diffuse new technologies (Edquist, 1997). Something similar can be said of the recent attention to regional systems of innovation, and the role of spatial proximity in facilitating organisational learning through the mechanics of interaction (OECD, 2001a). Yet these tools alone do not adequately instruct the central players and decision-makers, who still need meaningful, future-oriented information and shared visions (or frames of reference) with the help of which they can anticipate the consequences of their choices and negotiate relevant strategies. Technology foresight is among the tools considered useful in this respect.

A wide range of forward-thinking tools is needed to face the challenges presented by a rapidly changing and increasingly complex world. Continuous monitoring of new technologies with early identification of promising application areas, the assessment of the future (social, economic, environmental, health-related, legal and ethical) impact of new technologies, and broad-scope examination of the interrelationships of society, industry and technology all add to the 'strategic intelligence' that is needed if choices that shape the future are to be made. Both technology-push and demand-pull approaches are relevant when examining these issues (Tübke et al, 2001).

Increasingly, during the past decade, the appropriate balance between top-down governmental innovation and research policies and bottom-up market-driven initiatives has been identified by technology foresight exercises that rank choices and develop consensus within national innovation systems (Etzkowitz and Leydesdorff, 1999). According to a widespread view, technology foresight has become a promising policy tool for 'wiring' up and thereby strengthening national innovation systems (Grupp and Linstone, 1999).

In other words, technology foresight techniques offer a means for facilitating the relations and interactions within the innovation system so that knowledge

can flow more freely among constituent actors and the system as a whole can become more effective. In addition to national needs, regional and international foresight efforts have been explored and promoted during recent years. Infrastructural differences between various sub-regions, the common interests and cultural backgrounds of nearby regions, and the need to reflect the viewpoints of small countries, are among the reasons behind these developments.

2.2 The objectives of technology foresight

In general, foresight exercises are intended to encourage better decisions, to facilitate forward-thinking and to increase preparedness for change. The strength of technology foresight lies in its ability to combine formal analyses and communication processes. According to a classic statement, a foresight exercise thus involves a systematic process in which an attempt is made *"…to look into the longer-term future of science, technology, and economy and society with the aim of identifying the areas of strategic research and the emerging generic technologies likely to yield the greatest economic and social benefit."* (Irvine and Martin, 1984).

The analytic and communicative features of technology foresight exercises are stressed in more recent definitions. For instance, in a European research group on regional foresight, the foresight exercise is described as *"a systematic, participatory, future intelligence-gathering and medium-term vision-building process aimed at present-day decisions and mobilising joint actions"* (FOREN, 2001).

Science and technology priority setting, improving the welfare of society, the development of technology and innovation policies, and the facilitation of international cooperation are among the most commonly stated general targets of broad-scope technology foresight exercises. How these targets are reached depends on the exercise, however. While some of the technology foresight exercises emphasise the value of information itself, others are more concerned with the need to provide direct input for decision-making (Kuhlman et al, 1999; Hjelt et al, 2001; Barré & Greaves, 2001; Zweck et al, 2001).

Technology foresight usually has three major objectives or 'raison d'être' (Barré, 2002b):

- *Science and technology priority setting*: Technology foresight is used to direct and justify decisions on science and technology priorities and on investment in the most promising areas.
- *The connectivity and efficiency of the innovation system*: Technology foresight is used to 'wire up' the innovation system through communication, cooperation and networking among the developers, producers and users of technology, and also by highlighting the need for better framework conditions, regulation and infrastructure.
- *Shared awareness for future technologies, opportunities and strategies*. Technology foresight is used to foster shared awareness of future technologies, markets and strategies through debate about those technologies and their impact on society (with participation of the civil society), and through better understanding of the drivers of change.

To summarise, it can be stated that technology foresight exercises contribute to the five Cs: ***C**oncentration* on the longer term, improved ***C**oordination* of the visions, intentions and actions of stakeholders, ***C**onsensus* on areas that seem promising, ***C**ommunication* about societal needs and opportunities in science and technology, and ***C**ommitment* to the implementation of policies that may be appropriate in the light of the exercise. Through this contribution, a better alignment in the articulation, execution and exploitation of research efforts can be reached (Martin, 1995).

2.3 Foresight methods and practices

The approaches adopted in national-level technology foresight exercises during the past three decades can be grouped into three clusters, depending on the dominant formal tools and practices (Hjelt et al, 2001):

The first cluster consists of foresight exercises building on the Japanese ***Delphi-survey tradition***, started in the early 1970s, and followed by similar exercises in South Korea, Germany and France during the 1990s. The basic idea is to construct an extensive set of statements concerning future technological developments and then allow a large number of experts to react to these. The realisation time of specific technologies and the relative position of one's own country/region/organisation are examples of topics in Delphi questionnaires. Although the focus has usually been on technological developments, this approach has also been used to examine societal and cultural issues (Austrian Delphi 1996-1998).

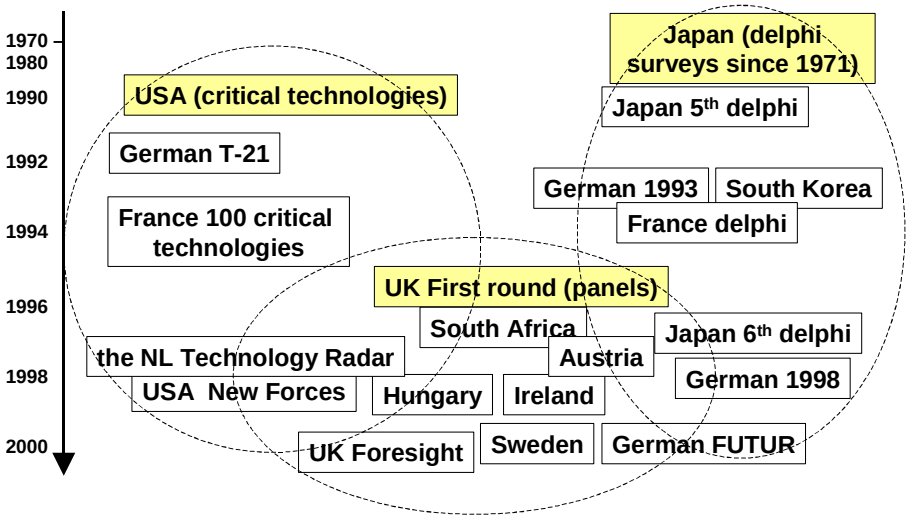
The second cluster is composed of foresight exercises where the focus is on identifying a list of ***'critical technologies'*** or ***'key technologies'*** according to predefined criteria (for example according to estimated economic and societal benefits). The main effort is put into defining the criteria, listing the technologies with potential in these respects, and assessing the individual technologies according to the criteria. Interviews, workshops and questionnaires are typically used as additional aids. This tradition was initially developed by the US government at the end of 1980s and it has been further developed in, for instance, Germany, France and the Netherlands. Although the focus here too has been on technological developments, there have recently been attempts to better consider the demand-side as well (for example, the French Key technologies 2005, 1999-2000; Durand, 2002)

The third cluster consists of foresight exercises organised as ***panel-based work around specific focus areas***. The number of panels varies (typically it is between 6 and 15). Commonly, the panel members come from various interest groups (industry, academia, government, NGOs, etc.). The panels typically form a relatively independent taskforce guided only by general guidelines. A wide range of formal tools and practices can be used by the individual panels. The choice of tools depends by and large on the panel itself. The panel approach was first developed in United Kingdom. It has been adopted and further developed in, for instance, South Africa, Ireland, Hungary and Sweden.

The panel approach has become increasingly popular in European foresight exercises. Because the various technology foresight approaches have influenced each other — especially during the past decade — the borders between the three clusters are not clear-cut, however. A critical step in each approach is to define who are the experts in the field. The conditions of information exchange must

also be attended to: the expert's ability and willingness to contribute might depend, for instance, on the degree of confidentiality and anonymity (see e.g. Eerola, 1996; Kuusi, 1996). Figure 1 illustrates the historical development and paths of influence of national-level technology foresight exercises.

Figure 1: Three clusters of technology foresight studies



Source: Hjelt et al, 2001

Technology foresight exercises can also be classified by the range of participation (scale of extensiveness) and the level of analysis (scale of intensiveness). This was recently done in connection with a large number of European exercises monitored by the European Science and Technology Observatory, ESTO (Barré, 2002a; Barré & Greaves, 2001). On the basis of this approach, it was possible to classify European technology foresight exercises into two categories: those designed according to the ***professional analytic model*** and those designed along the lines of the ***social process model***.

Exercises where the main emphasis is on ***producing well-grounded expert information*** fall into the first category, i.e. the 'professional analysis' (or 'professional brainstorming') model. The participants in these exercises are mainly science and technology experts. In technology or sector-specific studies, deep analyses of specific problem areas are possible. In technology foresight exercises with somewhat wider scope, well-structured pragmatic analyses at more general level are more typical. The examples examined in the ESTO study come from France, Portugal and Spain, but this type of exercise is carried out in other countries too — using, perhaps, labels other than 'foresight' (see the comments on 'technology forecasting', 'technology monitoring' and 'technology road mapping' below).

In the social process model of technology foresight the main emphasis is on ***generating shared visions***. The participants typically represent a broad social spectrum, or at least the most important interest groups connected with the relevant developments in science and technology (academia, industry, and government). Wide participation usually means that the analyses and results are presented at a general level. Well-structured pragmatic analyses can, however,

be found in smaller-case exercises still involving participants from different interest groups. The examples examined in the ESTO study come from Austria, Germany, the Netherlands, Belgium, the United Kingdom, Finland and Sweden (see Barré & Greaves, 2001).

The prerequisites and consequences of technological development are examined under a number of headings other than 'technology foresight'. '***Technology monitoring'***, 'monitoring of new technologies', 'early signal monitoring', '***technology forecasting***', 'technological forecasting' and '***technology road mapping***' are some of the headings used where more specifically focused technology foresight exercises are concerned. Exercises under these labels are typically carried out by individual organisations (universities, research institutes or companies) or in working groups coordinated by industrial federations or international associations. In particular, 'technology road mapping' has become increasingly popular among various development communities focusing on technological developments in their specific fields of interest. Work is also done under the headings of *'**futures research**'* and *'**futures studies***', particularly when societal and environmental aspects of technological developments are being examined.

The role of social interaction and the involvement of relevant interest groups (academia, business/industry, policy-makers) has been stressed in the context of technology forecasting and technology road mapping as well. Technology forecasting and technology road mapping exercises thus serve as communication platforms for identifying technologies and problems that deserve consideration, for estimating the timescales for realising the promise of the new technologies, and for informing key actors and the wider public of any actions needed to support desirable developments. Although the focus is on technological developments, an examination of socio-economic aspects is often integrated in the process (Holtmannspötter et al, 2001; Zweck, 2002; Groenveld, 1997; Kostoff et al, 2001; Naumanen, 2001; Probert & Shehabuddeen, 1999).

Work of a technology foresight kind is undertaken even in the field of ***technology assessment***. Technology assessment may be technology driven: examining positive and negative impacts of specific technologies, together with the present and desirable framework conditions. Or it may be problem-driven: examining technological solutions that have the potential to solve specific societal problems. Technology assessment is not just desk research. It requires the organisation of processes that enable the gathering of information, viewpoints and opinions from a broad range of experts and stakeholders. In order to ensure that the viewpoints of ordinary citizens are heard when new technologies are assessed, participatory methods supporting the process have been developed especially in Denmark, Germany, UK (see, for example, Andersen & Jaeger, 1999). The presentation of the resulting knowledge in a digestible form to decision-makers is another important contribution of technology assessment.

In addition to advising parliaments and politicians (perhaps the most visible and established form of technology assessment in Europe), a ***'constructive technology assessment'*** approach has been increasingly integrated into the development of new products and technologies. When it is closer to the innovation process, technology assessment is also closer to technology foresight. In Germany, for instance, the Federal Government has launched a new concept of ***'innovation and technology analysis'*** in order to avoid the

negative, 'backward-looking' connotations of the term 'technology assessment'. In Finland, parliamentary technology assessment is coordinated by the Committee for the Future, and this means that parliamentary assessment exercises increasingly resemble small scale technology foresight exercises.

Efforts to anticipate future developments deliver a variety of end results: the technology foresight exercise and related processes typically identify important technological topics and drivers, monitor weak signals, analyse technological trends and megatrends, formulate shared visions, and construct alternative scenarios and strategies. Which combination of these is fruitful depends on the focus and purpose of the study.

2.4 Defining the meaning of 'Nordic Technology Foresight'

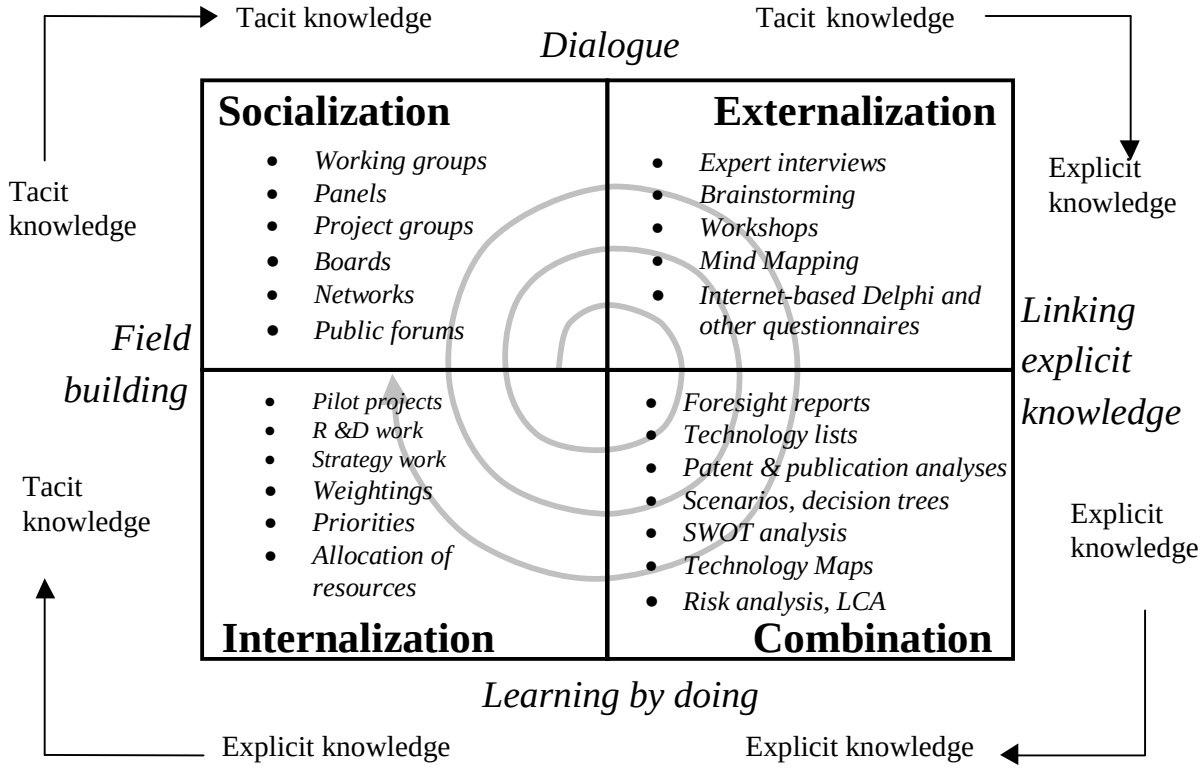
In examining the prospects for Nordic Technology Foresight, we need to define what we mean by the concept 'technology foresight' or 'technology foresight exercise' in the Nordic context. Drawing from the overview presented in the previous sections, and bearing in mind recent developments, we suggest the following definition:

Nordic technology foresight exercises are systematic, future-oriented interaction processes contributing to shared visions (or frames of reference) concerning long-term technological developments. In these foresight exercises, technological developments — together with their prerequisites and impacts — are examined in their real-world, economic and societal context, and attention is paid to a wide pool of knowledge and the viewpoints of various interest groups (including academia, industry and government). The processes can have a broad scope or be more narrowly focused. The purpose is to facilitate communication between the interest groups, and to increase the knowledge base of decision-makers and key actors, so that desirable technological developments can be supported with relevant Nordic strategies, decisions and actions. Both analyses and interaction are important in this respect.

If Nordic technology foresight exercises are defined as useful tools in shared knowledge creation (as in the above definition), a proper framework for examining and designing such processes seems to be the following model of organisational knowledge creation.[1] In this model, shared knowledge creation is envisaged as a spiral process in which tacit and explicit knowledge, as well as the different modes of knowledge conversion — i.e. socialisation, externalisation, combination and internalisation — play a central role. In Figure 2 the model is applied to the present context. This also helps to explain the various roles of formal tools and practices in technology foresight exercises.

1 The model has been originally applied in the field of innovation research, but is applicable in examining the processes of producing future-oriented information for decision-makers as well.

Figure 2: Technology foresight process — Useful tools and practices in the framework of knowledge creation



Source: Nonaka, 1994; Nonaka & Takeuchi, 1995; Eerola, 1996, 1997; Eerola & Väyrynen, 2002

According to the above model, our knowledge of future technological developments is a result of a dynamic interaction process where not only facts but also well-grounded views and opinions are treated as important ingredients. As it is not always easy to explicitly express all relevant knowledge, the presentation of valuable knowledge can be facilitated with the help of dialogues and formal procedures (structured expert interviews, brainstorming sessions, structured workshops, mind mapping techniques, Delphi-surveys etc.). Various pieces of explicit information must, however, be meaningfully linked to each other to make the resulting messages interesting. (The links can appear in the form of reports, technology lists, risk analyses, scenarios, decision trees, technology maps, etc.) Contextual interpretation and concrete application of the knowledge (learning by doing in the context of pilot projects, research and development, strategy work, defining weightings and priorities, the allocation of resources, etc.) deepens understanding, creating new tacit knowledge that is shared through socialisation processes. For instance, working groups, panels, project groups, boards and networks may be important field building forums in this respect. All these aspects must be considered when technology foresight exercises are designed in the Nordic context.

The challenges of shared knowledge creation are greater where the people participating in the technology foresight process and using the knowledge it creates have a heterogenous background. In the case of a Nordic joint exercise, the participants represent, not just various interest groups (industry, academia, government, NGOs, etc.), but also different countries, each with its own

language and cultural character. This means that special attention must be paid to the organisation of the process and to approapriate use of formal tools and procedures.

3 The Nordic countries as a common knowledge region

3.1 What is Nordic benefit?

Nordic cooperation rests on a long, shared history, which for centuries has influenced the political, economic and cultural ties among the Nordic countries. These ties foster shared values — values that are inherent in the Nordic welfare states, with their stable and well functioning democratic institutions, highly developed economic sectors, and safe communities. Following the foundation of the Nordic Council (1952) and the Nordic Council of Ministers (1971), collaboration has developed in a range of areas, including a common labour market, a passport union, and research and educational activities.

In an increasingly globalised world, in which economic and political ties span the globe, a key question is what in particular distinguishes Nordic cooperation from other international cooperations in which the Nordic countries participate. How do the spatial proximity and the cultural and historical ties contribute to the new learning economy? More specifically what is the Nordic benefit?

During the 1990s Nordic cooperation began to focus explicitly on Nordic benefits deriving from common activities and institutions. Two factors contributed to this (Brofoss et al, 2002: 12). First, after the fall of the Wall in 1989, the boundaries of the Nordic region were relaxed to include countries such as Poland, the three Baltic states, and the north-western part of Russia. Second, Sweden and Finland became members of the EU in 1995, and this raised questions about the impact of the EU on the Nordic cooperation and vice versa.

In the mid-1990s a new policy was formulated in the report 'Nordisk samarbejde i en ny tid' in which Nordic benefit was discussed for the first time. Nordic benefit should be obtained through (Brofoss et al, 2002: 13):

- Activities which otherwise would be conducted at national level, but where demonstrable positive effects are produced through common Nordic solutions.
- Activities that manifest and enhance Nordic cohesion.
- Activities that increase Nordic competence and competitiveness.

These principles still prevail. They appear at various levels and in different contexts of the Nordic cooperation, including contracts, selection and evaluation criteria for the assessment of project activities, the Nordic administrative handbook, and so on.

3.2 Building a Nordic knowledge region

Cooperation between Nordic countries in the areas of research, education and innovation is not a new phenomenon. The nature of this cooperation has,

however, developed over time. While in the past Nordic cooperation had a primarily internal focus, the future will see a shift of focus towards external cooperation with other countries. This will safeguard Nordic interests internationally. It will also mean a more concentrated effort within Nordic cooperation on fewer areas, with the aim of making a greater impact (Newsletter Norden – the Top of Europe No. 2, 2001). This approach was highlighted in the New Nordic Agenda (agreed on at the 53rd Session of the Nordic Council in Copenhagen in the autumn 2001), which is an overall political assessment of the future agenda of Nordic cooperation.

The potential to achieve synergy in an integrated Nordic knowledge region have been analysed in two recent studies[2] compiled by the Nordic Council of Ministers (Nordisk Ministerråd Næring 2001). These mention the following needs:

- To increase access to knowledge and information on the opportunities of creating interaction and of forming networks and strategic alliances in the Nordic region.
- To reinforce cooperation between Nordic research units and technological service institutes.
- To coordinate research, innovation, and industrial policies in the Nordic countries with a view to adopting more uniform rules for companies.
- To accord a higher priority to joint measures in areas of industry that represent positions of common Nordic strength, e.g. in areas such as medical and health technologies, energy and the environment, food (from soil to table) and information and communication technologies.

In what follows, the conditions of finding better Nordic synergy in science and technology are examined more closely from two viewpoints. The cooperative infrastructure of academic research and researcher education is first briefly described, with attention to most recent developments and policy outlines. This overview is followed by an outline of the recently launched collaboration programme on industrial development policy.

Nordic cooperation in academic research and researcher education

Nordic cooperation in the fields of academic research and researcher education has a long history. It was intensified by the establishment of the Nordic Council in 1952, and the present legal framework was laid down in the Nordic Cultural Convention ("kulturavtale") in 1971. Responsibility for policy formulation in Nordic research cooperation has been distributed among various bodies within Nordic organisations. Since 1983 the Nordic Research Policy Council (FPR) has had an advisory role in strategic issues relating to Nordic research cooperation (Luukkonen & Niskanen, 1998).

For academic researchers and university students, the Nordic Academy for Advanced Study (NorFA), established in 1991, together with research council cooperation in humanities and social sciences (NOS-H, NOS-S), medicine (NOS-M) and natural sciences (NOS-N), forms the basic Nordic cooperative framework. In addition, Nordic cooperation is fostered by separate research programmes focusing on problem-specific and sector-specific issues. (The

2 "Konkurrencekraft i Norden – muligheder og barrierer for erhvervsmæssig synergi i Norden" Oxford Research for Nordic Council of Ministers, 2000. "Kortlægning af den teknologiske infrastruktur i Norden", COWI for Nordic Council of Ministers, 2000.

programme “Norden och Europa”, the recently launched Welfare Research Programme, the Nordic Energy Research Programme (NEFP), and the Nordic Forestry Research Programme (SNS) are examples.) As a whole, Nordic research cooperation and researcher education is quite fragmented, however. During the years 1995-2002 there has also been a slightly decreasing trend in the resources available for the purpose. Compared, for instance, with EU and national funding of Nordic R&D activities, the resoruces devoted to Nordic cooperation are quite modest.[3] (www.norden.org; Hansen & Ståhlberg, 2001; NMR: Budgetudvieckling, Undervisning & Forskning, 2002).

The aim of Nordic research cooperation is to:

- facilitate researcher mobility, competence development and net-working;
- mobilise national co-funding for Nordic research;
- facilitate division of labour and specialisation in Nordic countries;
- facilitate Nordic participation in European and international R&D work.

The outline of a general strategy for Nordic research cooperation was presented in the paper “Nordisk Forskningspolitisk strategi — Sammandrag af Nordisk Forskningspolitisk Råd’s forslag (NMR, 1998). The paper suggests that Nordic R&D cooperation should be subject to a research policy strategy, and that a new financing model (the socalled ‘trappemodel’) should be introduced. It also recommends the implementation of a decision procedure in which there is a clear division of responsibility between the political, the research advisory and the research implementing levels. This strategy was approved in late 1998.

The Nordic Research Policy Council is coordinating the ongoing process of strategy implementation. The need for cross-sectorial and multidisciplinary research has been underlined. It has also been stressed that research and universities should serve not only the research community but also the wider society. Communication and cooperation with industry is thus encouraged (www.norden.org/c2_2000/). According to a paper entitled “Norden som en internationalt framstående forsknings- og näringsregion” (NMR, 2002) approved by the Nordic Council of Ministers of Education and Research in June 2002, Nordic research cooperation should aim at “developing Nordic region during the next 10 years into the most attractive region in terms of education, research and industry”. An anchoring on national-level priorities, investments and institutions — as well as further developments in the cooperation of universities, industry and the public sector — are seen as prerequisites for reaching this target.

As a result of European and global developments over the past two decades, there is a need to reassess the role of Nordic research cooperation. In particular, participation in EU research programmes has become increasingly important, not only for member states but also for the other associated Nordic countries (Luukkonen & Niskanen, 1998). New features have also entered into the Nordic

3 The total budget for Nordic research cooperation and education was 234.7 MDKK in 1995 and 195.8 MDKK in 2002 (using 2002 price-level). For example in 2000, the Nordic Council of Ministers allocated 103.3 MDKK to Nordic research cooperation. researcher education and networking through NorFA was supported with 35.0 MDKK, whereas the Nordic research programmes received 25.8 MDKK. Various Nordic research institutes (NORDITA, NIfS, NIAS, NORVULK, NSI, etc) received in total 45.8 MDKK in 2000.The support for Nordic Energy Research and Nordic Forestry Research was 1.0 MDKK and 5.4 MDKK respectively (www.norden.org/c2_2000/). Nordic scientific periodicals - especially periodicals in the area of humanities and social sciences - receive some support too.

cooperation framework itself: research cooperation with nearby areas (e.g. the Baltic and Arctic regions) is being promoted, and the Nordic framework also supports European cooperation (mainly at political level). In 2000, 72% of monetary support was budgeted for Nordic cooperation, 19% for cooperation with adjacent areas and 9% for cooperation in the European context (www.norden.org/c2_2000/.)

The issue of raising the international visibility of Nordic research with the help of appropriate cooperation is currently on the agenda of the Nordic Council of Ministers of Education and Research. One important step to this direction is the recent announcement of the joint pilot programme 'Nordic Centres of Excellence' launched by the Joint Committee of the Nordic Natural Science Research Councils (NOS-N). It will focus on basic, natural scientific research in the area of global change (specifically, on atmospheric, oceanographic and ecosystem processes in climate change).[4] This is a pilot programme with a relatively small budget. Its aim is to trial the feasibility of the centre of excellence concept in the Nordic research cooperation. The selected Centres of Excellence can be either virtual organisations that consist of research units in three or more Nordic countries or outstanding existing research units that provide equipment and infrastructure for researchers coming from other Nordic countries too. The objectives of the Nordic Centres of Excellence programme are to:

- increase the visibility and attractiveness of Nordic research in Europe and other parts of the world;
- ensure the effective and flexible allocation of resources and infrastructure;
- support creative and efficient research environments;
- create critical Nordic mass;
- increase the mobility of young researchers;
- create cooperation between different disciplines;
- support appropriate/reasonable specialisation between Nordic countries;
- integrate Nordic Centres of Excellence into national-level research systems.

Nordic Centres of Excellence may, then, increase the international visibility of Nordic research in Europe and elsewhere in the future. If properly managed and organised they will also enhance industrial research and development work. In reality, however, clear visions and concrete strategy outlines will be needed if their objectives are to be met. In addition to general-level visions and strategies, problem-specific and issue-specific road maps will be required.

Nordic cooperation within industrial development

The 'Nordic collaboration programme on industrial development policy 2002-2005' will play an important role in the creation of an integrated Nordic knowledge region. It is the first programme of its kind, with funds of approximately 66-67 million NOK each year, of which the Nordic Industrial Fund and Nordtest receive most. The idea behind was that each of the Nordic countries on its own was too small to effectively meet the challenges of globalisation, but that together they would create a critical mass and be able, proactively, to influence the broader international agenda (Nyhedsbrev No. 1/2001).

4 The first call for application of Nordic Centres of Excellence was in spring 2002. The selection will be made by October 2002 (www.aka.fi).

The goals of 2002-2005 are to (Nordic Council of Ministers, 2001):

- promote the Nordic region as internally borderless and, therefore, a better functioning and more competitive environment for business development;
- improve the international competitiveness of Nordic companies in certain specially identified sectors and corresponding accessibility to certain strategic development resources.

To achieve these goals, a number of measures have been formulated, although their adoption awaits further action and funding:

1. Competitive rules and an attractive business environment (including inter alia better coordination of industrial legislation and collaboration on common standards).
2. Access to strategic development resources (including inter alia common innovation policy, networks, cross-border logistics, collaboration projects and exchange of experience).
3. Strategic development of industrial policy (including inter alia international benchmarking on taxation, routines, labour market laws).

The Nordic Industrial Fund will play an important role in launching and implementing the programme. Traditionally, this fund aims to lift national innovation initiatives, where appropriate, to a Nordic level, in order to add new forms of cooperation to national and international (EU) cooperation. The Nordic countries have large research and development resources. They build on strong national priorities as well the EU research system. What is needed, therefore, is a process in which the Nordic countries both create a political mindset for future research and development challenges in the Nordic countries and make more proactive and concerted plans regarding (R. Enquist, NIF, April 2002):

- the input side of the innovation system, where the Nordic countries need to maintain a critical mass and attract the best people. This requires openness and flexibility in the innovation system;
- the output side of the innovation system, where the Nordic countries have to build critical masses (or centres of excellence) within science and technology areas that can be linked to other areas in Europe and/or around the world.

The Nordic Industrial Fund has, for example, reflected the above industrial development goals in its recent criteria for funding. These include:

- *Advancing international pre-normative work* — successful Nordic development can lay the foundation for international standards of the future that conform to Nordic specifications and requirements.
- *Pre-eminence in areas of strategic importance to the Nordic knowledge market* — projects financed by the Nordic Industrial Fund should be of a sufficiently high standard to play a part in creating a world-class knowledge market in those fields perceived as strategically important to Nordic industry and the public sector.

The development and strengthening of strategic networks within specific industrial areas has also been highlighted by Rolf Næss, of the Norwegian Ministry of Industry and Trade, who was member of the administrative committee that prepared the strategy (Nyhedsbrev No. 1, 2001).

The Nordic countries as outstanding research and industrial region

In June 2002, the Nordic Council of Ministers of Education and Research gave its response to the Nordic Council's recommendations on how to sustain the Nordic research area (Recommendation 34/2001). They highlighted the Nordic dimension in international R&D collaboration by strengthening Nordic research and development. The overall goal was thus to develop the Nordic region into a world-leader in education, research and industry within the next ten years. Quite how that goal is to be reached is yet to be investigated, but the Nordic Council of Ministers will consider the following collaboration areas:

- *Nordic joint actions*, e.g. within EU Research Framework programmes, international research programmes, financing of resource-demanding equipment and international institutions.
- *Nordic researcher education courses or research schools*, e.g. start-up of Nordic researcher schools, international marketing of Nordic research environments and research education.
- *Nordic Centres of Excellence and Nordic institutions*, e.g. to allocate more Nordic resources to this sort of collaboration.
- *Interaction between research and industrial development*, e.g. to support public-private interaction through common meetings/events/facilities, to intensify cross-border cooperation through education and mobility of researchers and experts, and to identify strategic action fields within technology and application and Nordic clusters.
- *Thematic priorities for Nordic collaboration*, e.g. there is a need to strengthen basic and applied research within prioritised areas.
- *Research collaboration on the development of the Internet and its application*, e.g. to develop a profile for Nordic collaboration within the field, to link basic and applied research as well as industry within the field, to build consortia and to collaborate on virtual education and research.

Further the Nordic Council of Ministers of Education and Research discussed various models for the financing of the research collaboration, including co-financing of research programmes and joint actions, the opening of national research funds for other Nordic researchers, and the possibility of setting up a Nordic research fund.

3.3 Enhancing strategic intelligence in the Nordic knowledge region

Nordic cooperation within research, education, and innovation takes advantage of shared values that are inherent in the democratic and economic institutions of our welfare states. A long tradition of cooperation has also contributed to our understanding of the potential of this kind of cooperation. There is nevertheless room to create Nordic benefit and thereby to add value to activities that can be solved more effectively at the Nordic level or that contribute to Nordic cohesion or increase Nordic competence and competitiveness. Nordic cooperation has in the past had a more internal focus, but present activities within research, education and innovation are outwardly focused on increased cooperation with neighbouring and other European countries.

Research policies emphasise excellence and the building of attractive and dynamic research environments by, on the one hand, facilitating mobility, competence-building and networking in a larger European context, and on the

other hand, facilitating some division of work and specialisation among the Nordic countries. Likewise, industrial development policies have a strategic outlook in terms of assuring an attractive business environment, appropriate development resources and a good framework in which companies can compete. With the statement from the Nordic Council of Ministers in June 2002 that, within ten years, the Nordic region should develop into a world-leader in education, research and business an important step has been taken that gives direction to the various activities and policies already undertaken. The precise way in which the goal is to be reached is yet to be investigated, but a number of collaboration areas have been highlighted, including joint actions, researcher education, improved interaction between the public and private sectors, thematic priorities, and research collaboration on Internet issues.

Although an overall goal has been described, effective mechanisms that can embrace the various activities and initiatives at the Nordic level appear to be as yet undeveloped. It is not a question of identifying the lowest common denominator, but of developing consensus on common, promising scientific and technological areas in the global knowledge economy. And it is not a question of starting from scratch, but of building on historical and cultural ties among the Nordic countries and thus consolidating Nordic cooperation. Here a Nordic technology foresight exercise may be a promising tool in strengthening a Nordic knowledge region — both internally, by building critical masses within selected areas of strategic importance to the Nordic region, and externally, by positioning common Nordic actions and alliances in a broader international context. In this respect technology foresight may act as a *gear change* between national research and development activities and the larger European research system within Nordic priority areas.

4 Technology foresight in the Nordic countries

4.1 Introduction

This chapter describes technology foresight activities in the Nordic countries in the context of the national innovation system.

For each of the Nordic countries, we give a brief overview of the science and technology infrastructure. This refers to those institutions in the national innovation system that support the creation and use of knowledge. Technology foresight or other activities contributing to forward-thinking are then presented. The description is not exhaustive in coverage. It aims instead to highlight the most important players and to set out their activities in the field.

Nordic countries are described in the following order: Denmark, Finland, Iceland, Norway, and Sweden. Also, foresight is looked at in the context of cross-border cooperation where it has proved to be a promising tool to bring people and systems together across national and institutional boundaries.

4.2 Denmark

Box 4.1: Danish Facts and Figures

Population – 5,349,200 (2001)
Area - 43,094 km2
Inhabitants/km2 – 123.8
GDP/inhabitant – 30,393$ (2000)
Important economic sectors – food, pharmaceuticals, manufacturing industry
Total R&D Expenditure / GDP – 2.06% (1999)
Government financed R&D / GDP – 0.67% (1999)
Industry financed R&D / GDP – 1.19% (1999)

Source: Nordic statistics; OECD, 2001b

The Danish science and technology infrastructure

The Danish science and technology infrastructure has been reorganised very recently with a new government in office. The key players are:

The new and powerful *Ministry of Science, Technology and Innovation* has overall responsibility for the 11 Danish universities (research and education), industrial research and Denmark's policy on technology and innovation. While the universities have been placed under the new ministry, the 25 sector research institutions — a mixed group of institutions in terms of tasks and size — are under various ministries. For example, the Danish Institute of Agricultural Sciences is overseen by the Ministry of Food, Agriculture and Fisheries and the National Environmental Research Institute is overseen by the Ministry of Environment. The ministry has responsibility for innovation. It also has a number of instruments to support the creation, diffusion and application of knowledge and new technology in the Danish economy. These include the ten Danish authorized technological service institutes (GTS), centre research contracts, innovation clusters, and technology foresight.

The research advisory system has an intermediary role between policy and science through its two basic tasks: a policy advisory task vis-à-vis the parliament, government and ministry, and a funding task. The overall advisory task is met by Denmark's Research Council, while the funding task is mainly met by the six research councils and Danish National Research Foundation. The Research Education Council and the advisory research committees in sector ministries have similar funding tasks.

The Ministry of Economy, Trade and Industry has as one of its responsibilities regional business development activities. Here, important instruments are the regional technological information centres and the venture fund known as "Vækstfonden".

The *Ministry of Education* also contributes to the Danish science and technology infrastructure, particularly through its activities within vocational and technical education.

Until very recently, Denmark was one of those countries in which technology foresight activities were not considered an appropriate tool for strategic decision-making, connectivity and efficiency, and awareness-raising about future technologies. Instead, forward-thinking activities were performed in various sectors, in particular in the energy sector, and technology assessments were performed with one eye on the problems and challenges within controversial technologies — for example, biotechnology and surveillance. However, in recent years more and more technology foresight activities have been performed at various levels in government, academia and industry. These activities have had diverse objectives, used a range of methods and tools, and generated a variety of results.

Technology foresight activities in government

Ministry of Science, Technology and Innovation
In 2000, the Danish government earmarked 24 million DKR to a national technology foresight project for the period 2001-2004. The policy initiative was initially dealt with by the Ministry of Trade and Industry, but with the new government in November 2001, it has been moved to the Ministry of Science, Technology and Innovation.

The aim of the technology foresight project is to identify action fields for developing and using new technology in Danish companies and Danish society. Policy initiatives will therefore be directed at research, education, regulation, consumer policy and technological infrastructure. At the same time the project may foster new contacts and relationships between private companies and public research and knowledge institutions (Regeringen, 2000a).

The technology foresight project was originally part of a comprehensive strategy — the so-called 'dk21' strategy — whose aim was to ask how industrial development policy can support the development of a sustainable society. Although this ambitious strategy has been abandoned by the new government, the technology foresight programme has survived.

The Danish technology foresight project builds on a number of previous actions (see for example Regeringen, 2000b; Joergensen, 2001a):

- The National Research Strategy devised by the Ministry of Research and Information Technology in 1997. This national strategy was formulated bottom-up in dialogue with the research system. Views on societal needs were also taken into account. The final priority-setting balanced the political demand for priorities and the wishes of the traditionally autonomous academia.
- The cluster analyses of business competitiveness prepared by the Ministry of Trade and Industry from 1994 and onwards. The Porter approach played a significant role in the business and industrial development policy of the previous government and concentrated on improving the framework conditions under which companies compete. In addition to the cluster analysis, further analyses have been carried out, including an international benchmarking analysis of industrial competitiveness, a trend analysis and a regional cluster analysis.
- A strategic stance on sensor technology prepared by the Ministry of Trade and Industry. A four year sensor technology programme earmarks app. 100 million DKR for research and innovation in centre contracts, industrial PhDs and improved knowledge and communication on technological trends.

The centrepiece of the programme is the creation of the Sensor Technology Center A/S, at which five approved technological service institutes are represented. This organisation will help to make available the knowledge and competencies that were needed to develop, produce and use sensors. It will do so mainly by building up networks. The sensor programme involves six research contracts. It also grants funds to encourage special efforts on sensor technology and industrial PhDs.

- A proposal for a national technology foresight project handled by the Board of Technology and co-financed by the Ministry of Trade and Industry in 1998. Although it was not approved, the report on technology foresight methodologies was widely accepted by a range of political stakeholders. This may have encouraged parliamentary support for the national technology foresight project during negotiations on the financial budget for 2001.

Compared to other European such programmes, the Danish technology foresight programme is a four-year pilot project with limited financial and human resources. The basic idea is to test the potential of foresight as a policy-making instrument in the Danish context, and to do so in particular for those ministries with substantial responsibility for the innovation system broadly understood — i.e. the Ministry of Science, Technology and Innovation, the Ministry of Education, and the Ministry of Economy, Trade and Industry (Darmer, 2002).

In summer 2001, a programme infrastructure was devised at the Agency for Trade and Industry. A small secretariat of three civil officials was set up, and some months later two advisory working groups were established: a research advisory group with experts from research and industry, and a larger reference group with participants from the academic and economic sectors.

It is expected that, during the four-year period of the programme, 10-12 foresight studies will be carried out, the aim being to conduct two or three foresight exercises per year. In 2002, three technology foresight exercises are being conducted within the following areas:

- Pervasive computing
- Green technology
- Medical and health technology

The selection of the three areas is not based on a systematic selection process. It partly reflects the political priorities of the previous government, and is partly the result of the fact that the foresight secretariat has opted for a flexible, ad hoc procedure in which themes are not identified a priori (Darmer, 2002).

The Danish Energy Authority

It is the responsibility of the Danish Energy Authority to lay down guidelines on the best possible production and distribution of energy, having consideration for such issues as security of supply, cost-efficiency and international commitments. It prepares forecasts of future developments in the field of energy in order to ensure that various energy-policy measures are based on sound and fair decision-making. In addition, the Authority assesses and compares different energy measures in regular feasibility studies. An example is the analytical report “Danmarks Energifremtider”, published in December 1995, which outlined two extreme potential energy scenarios compromises between which were discussed with a wide range of stakeholders. And later in 1996 the government approved its strategic energy action plan “Energi21”, which stated

clear goals for Danish energy policy within a timeframe of 2005-2030 and set out an action plan on how to reach those goals.

The Danish Board of Technology (Teknologirådet) is an independent, advisory body under the Ministry of Science, Technology and Innovation (www.tekno.dk). It has obligations to follow the technological development; to initiate technology assessment on the opportunities and consequences (for society as well as for the single citizen) connected with technological developments; to further public debate on technology; and to advise Parliament, the government and other political decision-makers. The scope of the Board's activities is extensive and covers strategic analysis, technology foresight, public debate, technology assessment, stakeholder dialogue and parliamentary advisory functions. Consequently, the Board applies a range of methods in its work:

- Experts may conduct analyses offering an overview of the issue. If experts are requested to make assessments, the Board normally makes certain that it consults several experts with different approaches, possibly setting up an interdisciplinary working group.
- Citizens may formulate objectives, visions, requirements and needs. Scenario workshops and consensus conferences are examples of methods in which citizens play an important role as assessors.
- Technology assessment may also focus on presenting information to the participants in such a way as to give them an opportunity to debate the issues. This method provides participants with background material on the basis of which they can make their own assessments.

Examples of recent technology assessment projects are: Clinical Information Systems, Ageing Society, GMO Plants and the Third World, Technological Solutions for Local Communities, and Hydrogen in a Renewable Energy System.

Technology foresight activities in academia

Risø National Laboratory is a national laboratory that carries out research in science and technology, opening up new opportunities for technological development. Risø research supports sustainable developments within energy, industrial technology and bioproduction. At the initiative of a board member from industry, a research programme was launched in 1998 to build competence within the field of technology foresight. The research programme Technology Scenarios is run within the Systems Analysis Department. Its aim is to carry out analyses of commercial, societal and scientific possibilities, and to clarify their implications for the selection, development and commercial application of new technologies. The research focuses on two themes. The first is technology foresight and evaluation studies for strategy and priority setting in science and technology. The second is the integration of foresight and technology assessment (i.e. life-cycle assessment, risk assessment). Research projects conducted by a cross-disciplinary group comprise, for example, Technology foresight on gene modified crops, Sensor technology foresight (together with the Sensor Technology Center A/S), Decentralised generation technologies in the liberalised EU electricity market, Life-cycle assessment and foresight in the wind turbine sector, Experience curves as a tool for assessing the impact and cost-effectiveness of different energy policy programmes, and the New Research Strategy for Risø National Laboratory.

The Technical University of Denmark and its Foresight Network consists of a number of professionals from primarily academic, research and governmental institutions in Denmark, who in their daily work deal with issues broadly concerning technological development and change, and how technology is best addressed in the context of more general (e.g. societal, economic, industrial or environmental) matters. The Network is a forum in which its members and other interested parties can conduct an ongoing discussion as to how the study and analysis of technology is best approached, drawing on the rich spectrum of disciplines in technology studies represented in the Network's membership: futures studies and technology policy (e.g. foresight initiatives), the history and sociology of technology, technology analysis and technology assessment, to name but a few. The Network will particularly aim to pick up on knowledge and traditions that are characteristic in Danish initiatives involved in the study and analysis of technological development and change.

The Royal Danish School of Pharmacy's Department of Social Pharmacy performs research in three main areas: Medicine use, Pharmacy and Public health pharmacy. Some researchers use foresight methods such as Delphi-studies to assess future drug requirements. Examples of foresight research are: Future's medical optimised body, Future drugs, and Prospective scenarios — a developing tool for the pharmaceutical profession (www.dfh.dk/instits).

Technology foresight activities in the private sector

The Confederation of Danish Industries is an interest group to which Danish employers belong. It is represented in numerous governmental and policy settings where the existing and future conditions and framework for Danish companies are discussed, negotiated and agreed. Already in 1992 it was assisted by the Copenhagen Institute for Future Studies in a study, called '1993 + 10', on economic, demographic, technological and political trends with an influential impact on Danish companies and their competitiveness. This study generated three scenarios for the future and a number of exciting opportunities for Danish industry. In 1999 the Confederation of Danish Industries participated in the preparation of the technology foresight report presented by the Board of Technology. It thus became very involved in the technology foresight matter again. At the same time, representatives of the Confederation of Danish Industries agreed with two trade unions to tailor a foresight project to the specific needs of Danish companies. So a pilot project was designed together with the Technology Scenarios group at Risø and sponsored through a common fund, "Industriens Uddannelsesfond".

Recently, other interest associations such as *The Society of Danish Engineers* (IDA) have engaged in foresight activities as a means to develop their own organisation and to influence proactively the role of technology in the creation of the welfare state (www.ida.dk/). The technology foresight project focuses on future energy supply as this is considered to be one of the central technological challenges facing society in terms of its economic, environmental and security of supply aspects. Two technology foresight exercises have been undertaken in parallel: technology radar within energy systems and a foresight for fuel cells.

One of the traditional players in future studies is *The Copenhagen Institute for Futures Studies*. It was founded in 1970 and set up in cooperation with a number of organisations wanting sound bases for decision-making. It conducts a number of research projects for public and private companies and organises

member activities such as conferences, theme meetings and wild card meetings (www.cifs.dk).

Larger companies such as *Grundfos A/S* are also using technology foresight methodologies in their strategic activities.

4.3 Finland

Box 4.2: Finnish Facts and Figures

Population – 5,181,115 (2001) Area – 338,145 km2 Inhabitants/km2 – 15.3 GDP/inhabitant – 22,156$ (2000) Important economic sectors – electronic industries, forest industries Total R&D Expenditure / GDP – 3.22% (1999) Government financed R&D / GDP – 0.94% (1999) Industry financed R&D / GDP – 2.16% (1999)

Source: Nordic statistics; OECD, 2001b

The Finnish Science and Technology infrastructure

The Science and Technology Policy Council is a high level body directing science and technology policy in Finland. It deals with the overall development of scientific research and education and prepares issue statements on the allocation of public science and technology funds to the various ministries and research fields. The Council is chaired by the Prime Minister. The membership consists of seven ministers, as well as ten other members who are familiar with science or technology issues (representatives of the Academy of Finland, Tekes, industry as well as employers' and employees' organisations). The government appoints the Science and Technology Policy Council for a three-year term. Correspondingly, the guidelines and issue statements are made public in triennial policy documents (VTTN, 2000; Eela, 2001; Lemola et al, 2000).

The two most important ministries in the Finnish R&D system are the Ministry of Education and the Ministry of Trade and Industry. The Ministry of Education oversees all the universities and the new polytechnics that have been established since early 1990s. The Academy of Finland, composed of four research councils, is the central financing and planning body in basic research. The National Technology Agency (Tekes; www.tekes.fi), which is overseen by the Ministry of Trade and Industry, has a corresponding position in the planning and financing of technical research and applied R&D. The most important R&D institute operating under the Ministry of Trade and Industry is the Technical Research Centre of Finland (VTT). The other ministries are responsible for research that is carried out in sectoral research institutes like VATT, Stakes and METLA (Lemola et al, 2000; Rask, 2001; Salo, 1999). In total there are more than twenty such sectoral research institutes in Finland.

Other significant players in the Finnish R&D-system include the Finnish National Fund for Research and Development (Sitra). This is a relatively autonomous organisation which answers to the Parliament of Finland. Sitra's operating segments are technology transfer and seed finance, the financing of

growth companies and investments in venture capital funds. It is also interested in strengthening the links between research and societal decision-making through research and training. It funds and participates in various 'think tank' activities and has close connections with the Committee for the Future of the Finnish Parliament (Lemola et al, 2000; Salo, 2001b).

Regional R&D has played increasingly important role since the 1980s. In the 1990s new regional employment and economic development centres (TE-centres; see www.te-keskus.fi) were established. These centres are composed of state regional offices, which represent the Ministry of Trade and Industry, the Ministry of Labour and the Ministry of Forestry and Agriculture (Lemola et al, 2000). The regional TE-centres work in close cooperation with the National Technology Agency (Tekes).

Industrial federations are also key promoters of, and participants in, technology foresight studies, together with companies for whom future-oriented studies form an important part of strategy work.

Finnish foresight exercises

No large-scale, nationwide foresight exercises — of the sort undertaken, for instance, in Germany, the United Kingdom or Sweden — have been carried out in Finland. The only effort in that direction has been a pre-study "On the Road to Technology Vision" initiated by the Ministry of Trade and Industry in 1996 (KTM, 1997). This study focused on eight clusters of industry (a bio- and food cluster, energy, chemistry, transport and infrastructure, metals and machinery, forest cluster, construction and telecommunication) with a 10-20 years time horizon ahead. The objectives were to produce a well-structured picture of needs and opportunities arising in central technology fields from the Finnish point of view, and to generate a vision that would harness resources and energies towards common objectives. (In fact, the study was meant to be a preliminary stage for a high-level technology vision programme, but organisational changes in the Ministry and some other organisations responsible for the Finnish R&D policy caused some discontinuity in the further development of foresight activities at the national-level.)

Among the topics addressed in the Ministry's "Technology Vision" study were the future needs of a welfare society, and opportunities provided by science and technology, as well as future business developments. The entire production and innovation system was examined, taking into account the expected external conditions (such as developments of the global economy and mainstream technologies). The study was carried out by eight working groups with representatives from companies, universities and research institutes, ministries and funding organisations. The process was administered by The National Technology Agency (Tekes), and in each working group there were three to four core group members, supported by 15-30 experts that participated in the process as panel members or reviewers. In total, around 150 people representing research, industry, public administration and R&D funding were consulted during the study (KTM, 1997).

The work of the eight working groups was summarised in a written report that also contained conclusions concerning the development of national-level foresight activities in Finland. One of the conclusions was that there was no urgent need to nominate a specific foresight committee. Instead, it was considered more important to encourage interaction between the various actors

of the innovation system. Since Tekes technology programmes have been effective in this capacity for the past decade, there was no need to organise national-level foresight exercises for this reason.

The report "On the Road to Technology Vision" was sent for comments to key actors in the public sector, academia and research institutes and various NGOs. In total, 70-80 people from various organisations commented on the final study report (i.e. 50% of those who were included in the circulation of the comment procedure). A post-process seminar for the participants and the commentators was arranged in February 1998.

In autumn 2000 the Ministry of Trade and Industry took up the most recent initiative of the Science and Technology Policy Council (VTTN, 2000), concluding that there was a need to assess the present foresight practices in order to ensure that they will meet the future needs of the society. The assessment report commissioned by Professor Ahti Salo of the Systems Analysis Laboratory at Helsinki University of Technology was completed in February 2001. It suggested that a clear institutional frame in the form of a foresight secretariat would be needed to promote and support foresight exercises, and to better coordinate the diverse activities contributing to forward-thinking (Salo, 2001). Among other things, the report proposed that a foresight secretariat should be established to support national foresight activities. Its role would be to coordinate and promote foresight activities, to create and maintain international contacts and to take part in the preparation of foresight projects.

Along the lines suggested in the assessment report, a four-year foresight development and coordination project was started in the Ministry of Trade and Industry in summer 2001. The implementation plan of the project was finalised in January 2002. In particular, cooperation and coordination between the Ministry of Trade and Industry, Tekes and VTT will be aimed for in the course of the development project. The four-year secretariat consists of two (full-time and part-time) employees. A foresight expert group (some 15 people from various organisations, including MTI, Tekes and VTT) was established in September 2001, with the aim of supporting the work of the secretariat. Another support group, consisting of foresight users and representatives of funding organisations, is currently being negotiated.

In parallel with the developments described above, a new research programme called 'ProAct', focusing on the interaction between research, industry and society, was constructed. The official kick-off seminar of the programme, coordinated and funded by Tekes and the Ministry of Trade and Industry, took place in February 2002. In a departure from initial plans, no foresight projects were, however, included in the programme during the first phase. Instead, the Ministry of Trade and Industry is planning to support foresight exercises with separate seed funding.

In the private sector, technological developments have been anticipated by companies and industrial federations as part of their strategy processes. The cluster studies of the Research Institute of the Finnish Economy (ETLA) have also included examination of technological developments (see Heresniemi et al, 2001). In addition, studies of specific topics have been carried out in collaborative work undertaken by sectoral research institutes, academic researchers and private consultants (see e.g. Kuusi, 1991, 1994; Hienonen &

Lehtinen, 1995, Hienonen, 1997, 2000; Salo et al, 1998a; Lievonen, 1999;).[5] These joint studies have typically been supported by the National Technology Agency. Industry is also increasingly interested in 'technology roadmapping', through which, it is hoped, the processes of technological change will be better managed. Thus the Federation of Finnish Metal, Engineering and Electronical Industries (MET) has actively promoted this type of work (see e.g. Naumanen, 2001); and Finnish companies have been actively involved in technology roadmapping processes carried out by international industrial federations.

A number of sectorial and regional foresight studies have been conducted during the past few years. For instance, VTT Energy has recently completed its "Energy Vision 2030" study, and there are also several foresight studies in the fields of forestry, food technology, ICT and biotechnology. These studies have been carried out by VTT, Finland Futures Research Centre/Turku School of Economics, other university research groups and private consultants. The regional TE-Centres have also organised a series of foresight seminars (12 in all, focusing on various aspects of foresight). During the past few years technology foresight exercises have become a tool that is widely used by those developing regional strategies.

Other activities contributing to forward-thinking

A variety of parliamentary, governmental, institutional and regional practices also contribute to forward-thinking in technology-related policy-making and industrial strategy processes. Fostering continuous forward-thinking in decision-making and development communities has been seen as more important than establishing separate foresight institutions. For instance:

- A Committee for the Future focusing on the future developments of the Finnish society was established in the Finnish Parliament in 1993. It gained permanent status in 1999. The duty of the committee is to prepare broad-scope future outlooks for the next 5-15 years and to report on developments to members of Parliament. Furthermore, the government is expected to give Parliament a report on future developments of the Finnish society during each election period. These reports are taken into the general discussion of Parliament. The Committee for the Future processes the information further on the basis of expert statements, and the government is expected to conform to any issue statements accepted by Parliament (see www.eduskunta.fi).
- Since 1997, the Committee for the Future has also been responsible for parliamentary technology assessment. In particular, its duty is to inform members of Parliament of possible or expected societal impacts of new technologies. Parliamentary TA studies that have been carried out so far have focused on gene technology in plants (Salo, 1998b et al), technologies for life-long learning (Sinko & Lehtinen, 1998), technologies supporting the autonomous life of ageing people (Kaakinen et al. 1999; Eerola et al. 2001; Törmä et al. 2001; Kuusi, 2001), knowledge management (Suurla, 2001) and energy technologies (Kuusi & Loikkanen, 2001). The TA study currently in progress focuses, in turn, on human genome and stem cells. These TA studies have been ordered from various experts and research groups. When the technologies are assessed, economic, societal and social, as well as health and environmental impacts are examined, with attention

5 See also www.tukkk.fi/tutu, www.abo.fi/iamsr/cofi, www.gaia.fi

being given to ethical and legislative issues as well. The Finnish National Fund for Research and Development (Sitra) has supported the parliamentary technology assessment work during the past three years. The financial resources devoted to parliamentary technology assessment are scant, however.

- A significant number of foresight studies have been carried out under the auspices of the Ministry of Labour and the Ministry of Education. These foresight projects have been funded by national and European funds (ESF). However, the impacts of technological developments have not been explicitly considered (Salo, 2001). [6]
- The National Technology Agency has published future outlooks focusing on key technological developments (see e.g. Tekes, 1998). The reports have been prepared by in-house experts, taking into account available studies from external sources.
- In 1999 the Academy of Finland organised a 'Global Science' seminar in order to facilitate discussion of international developments in science. Universities have organised high-profile seminars with similar aims (e.g. 'Technology Trends' seminars organised by Helsinki University of Technology in 1998 and 2001). On the other hand, broad-scope round-table foresight exercises have also been undertaken by various professional associations and societies — for instance, by the Finnish Association of Graduate Engineers (TEK, 1999, 2000), the Finnish Association for the Club of Rome and the Finnish Society for Futures Studies (Kaitila, 1995).

In addition to these more or less explicit foresight activities, forward-thinking is embedded in the preparation of research programmes at the National Technology Agency and the Academy of Finland: in the form of vision statements on technological trends and associated opportunities, as well as organised workshops and seminars supporting networking and the identification of research challenges that call for concerted efforts. These activities have also influenced official calls for research proposals, although programme building is essentially a bottom-up process. On the other hand, technology, business and user-demand scenarios have also been included as parts of specific research programmes (see e.g. WoodWisdom and SmartMachines Programmes; www.tekes.fi). Municipalities, and many big companies have, in turn, developed scenario and vision building processes that are intended to strengthen the long-term view in strategic planning and decision-making.

Some new practices are developing at the regional level too. The government has organised regional future forums in various provinces in cooperation with the Committee for the Future of the Finnish Parliament (VNK, 2000). The TE-centres, in turn, have started to facilitate regional innovation processes by future-oriented outlooks on emerging new businesses, such as knowledge-intensive business services (see Toivonen, 2001), and by organising education and workshops that focus on future businesses and development in the operating environment. Some basic tools of futures research have also been introduced to the regional actors in these contexts.

6 In total, more than 15 million Euros has been devoted to more than 170 projects (see www.mol.fi/esf/ennakointi). The focus of the studies has been on the developments of working life and the ways in which the skills needed can be attained.

4.4 Iceland

Box 4.3: Icelandic Facts and Figures

Population – 283,361
Area – 103,000 km2
Inhabitants/km2 – 2.7
GDP/inhabitant – 30,302$ (2000)
Important economic sectors – Fishery, geothermal power, aluminium manufacturing, diatomite mining and processing, machine manufacturing, and biotechnology.
Total R&D Expenditure / GDP – 2.32% (1999)
Government financed R&D / GDP – 0.96% (1999)
Industry financed R&D / GDP – 1.01% (1999)

Source: Nordic statistics; OECD, 2001b

Science and technology infrastructure in Iceland

The key governmental player in the Icelandic science and technology infrastructure is the *Ministry of Industry and Commerce*. In recent years, the ministry has primarily focused on knowledge-based industries and services. One reason for this is that the traditional industries — owing to constantly increasing technical level and automation — are requiring a smaller and smaller workforce. Presently, the fastest growing sectors are within the fields of biotechnology and genetics, information and communication technologies, health technologies and pharmaceuticals, food processing machinery, power intensive industries, food processing, and financial services. The Prime Minister, the Minister of Industry and the Minister of Education are currently preparing a new bill relating to the science and technology council of Iceland. A policy group reporting to the Prime Minister will be established with two ministers (Education and Industry) as well as 14 members from different sectors of society. It should rest on the two pillars of science and industry, but at the same time it should focus on technology diffusion in order to create better conditions for converting knowledge into products.

Other key players are: *The Icelandic Research Council*, which plays a crucial role as the intermediate policy advisory body and funding institution between science and society; and *The New Business Venture Fund*, an autonomous, state-owned institution, which is intended to encourage innovation in Iceland through equity contributions, risk loans, risk loans with equity conversion, and projects.

Also the independent, public technological research and development and educational institution, *IceTec* is a key centre of applied research and technology transfer, particularly for clients such as small and medium sized enterprises (SMEs). Its primary aim is to strengthen the economy through development, innovation and increased productivity.

Although technology foresight in the strictest sense is not performed in Iceland, at different levels, public and private industrial and research institutions build their strategies and policies on advanced forward looking methods and analysis

and create consensus and commitment in an informal process in which key actors are heard as described below.

Technology foresight activities in government

The *Ministry of Industry and Commerce* informs its policy-making through an outspoken consultation process. The evaluation process consists, first, of a theoretical evaluation of the field, including the technical topics as well as market strengths and weaknesses; and second, of the selection of promising areas on which the ministry will concentrate its efforts with the aim of sustaining the competitiveness of the industry on the global markets. The process is organised in an organic/informal way. It draws on a group of central and interested experts and researchers, and includes in-depth studies that are frequently conducted by ad-hoc working groups of experts. The small size of the country makes it easy to communicate transparently with central actors and across different sectors without very formal procedures.

A recent example of this is the 'Minister's Policy and Actions for the years 2001-2003' (published March 2001). This policy paper was the result of several policy-making sessions headed by the Minister with the participation of key personnel of the Ministry. Another example is the policy paper 'The Role of the Ministry's Research Institutes in Innovation and Economic Development' (published September 2001). This paper was the product of a working group consisting of the three managing directors and the Ministry's director of innovation and was based on individual visions for the institutions.

A new three-year regional policy is to be prepared. This is a typical strategic process in which the main focus has been on framework policies on how to facilitate the diffusion of knowledge and the building of new knowledge-based industries and services. It will be organised in a way that overcomes the former conflicts and division between traditional sector ministries and economic and societal sectors.

When it comes to more formal technology foresight, the most important and by far the most extensive work currently being undertaken by the Ministry of Industry and Commerce relates to the master plan governing the utilisation of Iceland's hydro and geothermal resources
(see also www.landvernd.is/natturuafl/index.html).

The *Icelandic Research Council* has, before and after its reorganisation (involving a merger of the earlier National Research Council with the Science Council), conducted analyses of future developments within markets and technologies affecting the major economic sectors. These analyses support decisions about the allocation of research and innovation funds. They have been conducted for fisheries, aquaculture and agriculture, construction and production industries, but also more technology specific areas, such as materials, biotechnology, and information and communication technologies.

Biotechnology was prioritised in 1985, and today efforts are being made to promote strong interaction between basic science, applied science and innovation in the area of biotechnology and medical technologies. This action field has led to promising results and laid the foundation of more than ten biotechnology companies as well as new start-ups in health, medical device etc.. The analyses are typically produced during a process in which both scientific, industrial and other user viewpoints are heard. The analytical phase often leads

to consensus on visions for the future and generates action through agreement. Commitment is often made to stimulate specific projects and financing.

IceTec focuses on existing industries and their needs for assistance and consultancy on research and development. It does not conduct technology foresight as that is normally defined, but it calls upon small groups of experts when discussing and deciding on its strategy — for example, within materials and biotechnology. In an informal way, consensus is thus built up during this phase. The future outlook for industry has to include the traditional sectors of the economy, such as fisheries and natural resources, but should also look in new directions. There is widespread consensus that promising areas are the manufacturing industry and marine industry, the health sector and recently also hydrogen economy potentials within renewable energy and hydrogen fuel cells for land and sea transport.

Technology foresight activities in academia

The *University of Iceland, Science Institute* and one of its spin-off companies, Icelandic New Energy Ltd7, have a leading role in developing the Icelandic vision of the hydrogen society. The main objective of the company is to move from a carbon-based economy (fossil fuels) to a society driven by hydrogen. In recent years the increase of CO_2 emitted from cars and vessels, together with the newly established or extended metals industries (e.g. aluminium), has led to a situation where international regulation of greenhouse gases is difficult to fulfil. The challenge is therefore to solve this environmental problem. Iceland offers a good field test for the hydrogen economy. The vision comprises the following steps (see also Arnason & Sigfusson, 2000):

1. PEM fuel cell bus demonstration project. Up to three city buses in public transportation in Reykjavik.
2. Gradual replacement of the Reykjavik bus fleet by PEM fuel buses.
3. Introduction of methanol powered PEM fuel cells cars for private transportation.
4. PEM fuel cells vessel demonstration project. One research vessel with hydrogen stored on board in methanol.
5. Gradual replacement of the present fishing fleet by PEM fuel cell powered vessels.

Technology foresight activities in the private sector

The *Federation of Icelandic Industries* is an organisation with 1,400 members, ranging from small family businesses to Iceland's largest industrial enterprises. It monitors technology foresight results in the other Nordic countries. It regards future studies as tools to assess future challenges and has chosen a proactive approach. Therefore, it focuses on the will of its members and which meaning they give to the future. In that sense it is very close to an ordinary technology foresight exercise. Since the beginning of the 1990s, it has performed a range of future workshops. Typically, it performs four to five exercises a year covering specific industrial sectors and clusters as well as the whole industry. Each workshop involves the most active and important people from the sector in question: partners and actors with knowledge and an awareness of development, demands, supply and the business environment. The Federation of Icelandic

7 It is a joint venture established in 2000 by all major energy companies in Iceland (51%) plus international actors such as DaimlerChrysler, Shell International and Norsk Hydro.

Industries has developed effective ways of running these future workshops. It successfully motivates large numbers of people (typically 30-40) in a holistic strategy process, despite the fact that these people have heavy schedules. In a 24-hour process, starting from lunch time, the process delivers a description of how the sector (industry, companies or given products) will look like in a given year in the future — what results will be achieved and what factors are critical to success. The workshop participants also define and prioritise the activities whose implemention is most important if the desired future, or goal, is to be reached.

Other future vision processes are 'Forums of technology' (FoT), which bring together members from the producer/provider and user side of a technology. In particular two such forums have been running in Iceland — one in the field of fisheries technology since 1993, and one in the field of health technology since 2000. In Health Technology this has led to the 'Nordic Health Technology Forum', a body which is now under construction and financing phase. A coordinated Nordic Future Vision or forsight in the field of Health Technology would be an important element of such forum.

4.5 Norway

Box 4.4: Norwegian Facts and Figures

Population – 4,503,436 (2001) Area – 323,877 km2 Inhabitants/km2 – 13.9 GDP/inhabitant – 35,527$ (2000) Important economic sectors – oil and other mineral extraction, shipping, fishery Total R&D Expenditure / GDP – 1.70% (1999) Government financed R&D / GDP – 0.72% (1999) Industry financed R&D / GDP – 0.84% (1999)

Source: Nordic statistics; OECD, 2001b.

Norwegian science and technology infrastructure

The key actors supporting the creation and use of knowledge in the Norwegian science and technology infrastructure system include first and foremost the following institutions (Kuhlman et al., 2001):

The *Research Council of Norway* (RCN) has both a policy advisory role with the government and a funding function relating to basic and applied science. It was established in 1993, by merging the existing five research councils and was assigned a number of ambitious tasks, such as producing national and sectorial research policy advice, funding research to meet social and industrial needs, funding high quality basic and applied research needed in the national system of knowledge production, taking strategic responsibility for the research institute sector, promoting the interaction of national knowledge production and the international knowledge production system, and using appropriate and efficient processes and organisational structures in performing its tasks (Arnold et al, 2001).

The *SND* provides grants and loans for economic development and also programmatic aids to business development. These include grants to start-up companies, innovation grants, training in management, and identification and funding of research-based inventions for further commercialisation.

The *Industrial Development Corporation of Norway* (SIVA) is responsible for science and industry parks. It is co-owner of 44 industrial parks in Norway and one in Murmansk, and it has ownership status in 34 science parks, many including incubators. It operates venture and seed capital activities and also runs innovation and development companies, both within and beyond the science parks.

Various venture capitalists comprise the START Fund, the regional seed corn funds, regional venture funds and investment funds connected to SIVAs science parks.

As in Denmark, Finland and Iceland, no large-scale, nationwide foresight exercises have been carried out in Norway. But forward looking and future activities are undertaken at various levels in different institutions in the Norwegian research and innovation system. The following section highlights some of these activities in the Norwegian research and innovation system.

Technology foresight activities in government

The *Ministry of Labour and Government Administration* and the Norwegian government carried out a future oriented scenario project "Norway 2030" in the period June 1998 - December 2000 (Øverland, 2000; Øverland & Neumann, 2001). The main focus was on the future of the public sector and included 15 out of 16 ministries and more than 70 public servants. The background to the project was the transition from a petroleum-based off-shore industry to a mainland economy and the any ensuing changes in needs that will demand considerable public sector investments. The key issues addressed in the project were: What consequences of the changes can be envisaged for the national economy and for the services provided by the public sector? Will the current division of responsibility between the public and private sectors provide Norwegian society with an adequate basis for the timely development of a sound mainland economy? While this scenario approach was oriented towards process and learning among diverse actors, the previous future scenario projects for Norway — for example, Scenarios 2000 from 1987 and its predecessor Horisont 21 from 2000 — were primarily analytical projects conducted by researchers.

The *Research Council of Norway* (RCN) has recently prepared a new strategy, "Forskning for framtiden", in close cooperation with stakeholders from industry and academia. In this work technology foresight did not play a role, as the RCN has not previously regarded technology foresight as an appropriate means of prioritising research resources. For a small country like Norway, technology foresight has been considered to be too resource-demanding and time consuming to use as input in the strategy development of the Council. Instead there have been extensive hearing procedures on the overall strategy of the RCN, the strategic programmes, and the cross-cutting initiatives, which to some extent produce the same features as technology foresight exercises do elsewhere.

The Industry and Energy division is concerned with more down to earth and short-term (five-year) strategic studies that identify new strategic technology areas. Such studies have focused on generic technologies. In workshops with the active involvement of both industry and academia, the strengths and weaknesses of Norwegian research have been assessed within areas such as biotechnology, materials, the environment and construction, oil and petrol and so on. The RCN also takes advantage of a contract with the American Coates & Jarrett company. This company maps and screens existing foresight reports across the world and present the results once a year at a meeting of their many clients. What is missing, however, is a more overall and conclusive technology foresight process including all divisions of the RCN as well as external stakeholders.

This was highlighted in a recent evaluation of the RCN: "RCN could do better at being an **arena** where opportunities can be explored" (Arnold et al., 2001: 104). It also emerged that there was a permanent need for strategy and foresight functions such as strategic programmes, institutes and infrastructures; response mode/free research, strategic innovation agency, and absorptive capacity (Arnold et al, 2001: 123). Instead of describing actions against national research priorities the RCN had itself helped establish, it should rather prescribe actions and hence move from weak to strong coordination in implementing priorities (Arnold, 2001: 4).

For several decades the *Norwegian Defence Research Establishment* (FFI) has used perspective studies to attempt to make predictions concerning weapons development over the next 10-15 years. The identification of new technologies and foresight related processes are of crucial importance to the institute, especially in connection with the initiatives in strategic basic research and programme oriented basic research. Already, back in 1995, the institute recognised the potential of cooperation between the civil and the military sector regarding the monitoring and identification of new technologies (Sørlie, 1995: 13). However, it seems to have little communication with other research communities, which makes its foresight activities relatively unknown to people working in institutions outside the armed forces and indeed to many people within the forces (Øverland & Neumann, 2001: 12).

The *Norwegian Board of Technology* is an independent body for technology assessment established by the Norwegian government in 1999. It was first established as an independent body under the Ministry of Education and Research, but has recently been moved to the Ministry of Trade and Industry. The Norwegian Board of Technology works at the interface of science and technology. It addresses technological challenges and the possibilities of new technology in all areas of society. Furthermore, it stimulates public debate and supports the political opinion and decision-making processes. It monitors international technological development and the development of technology assessment methods (i.e. technology foresight methods, participatory methods etc.). Since its foundation it has conducted a number of projects — for example, an expert based scenario workshop on smart-home technology in welfare services for elderly people. Technological opportunities such as the future heating of houses and buildings and the hydrogen society, with special emphasis on fuel cells, will likewise be addressed in upcoming projects (see e.g. www.teknologiradet.no/html/463.htm).

Technology foresight activities in academia

The *STEP group* was established in 1991 to support policy-makers with research on all aspects of innovation and technological change, with particular emphasis on the relationships between innovation, economic growth and the social context. The foundation receives a core grant from the Strategy Unit of the Research Council of Norway (Sørlie, 1995). The basis of the group's work is a recognition that science, technology and innovation are fundamental to economic growth; yet there remain many unsolved problems about how the processes of scientific and technological change actually occur, and about how they generate social and economic impacts. The research of the STEP group centres on historical, economic, social and organisational issues that are relevant in broad fields of innovation policy and economic growth. In spite of the strong emphasis on tools for planning, evaluation and priority-setting in research and development, the STEP group does not work in the field of technology foresight (Sørlie, 1995). It should be mentioned however, that it has contributed to the future scenarios in Horisont 21 (see further below).

Norway's *SINTEF Group* is the largest independent research organisation in Scandinavia with more than 1,700 employees (www.sintef.no). The organisation provides knowledge and related services based on research in technology, the natural and social sciences and medicine. SINTEF's vision is of technology for a better society based on research-based knowledge and related services to Norwegian and international clients. The SINTEF foundation consists of eight research institutes, including Applied Chemistry, Applied Mathematics, Civil and Environmental Engineering, Electronics and Cybernetics, Industrial Management, Materials Technology, Telecom and Informatics, and Unimed.

Technology foresight activities include inter alia a national feasibility study on the hydrogen society that was carried out during the winter of 1999/2000. The purpose of the project was to conduct a national feasibility study into hydrogen as an environmentally friendly energy carrier. The report identified the expertise found at research institutes and universities, within Norwegian business and industry, along with possible technological and commercial priority areas of an international kind. The project was conducted in a cooperative endeavour involving SINTEF, the Norwegian University of Science and Technology, the Institute for Energy Research, and the University of Oslo. The information was collected chiefly through arrangements made at a workshop with nearly 100 Norwegian and three foreign participants.

Another important future study was conducted by *ECON Center for Economic Analysis*. In 1999 it published "Horisont 21 – Scenarier ved et nytt årtusen". The project was financed by a network involving a variety of private and public institutions in Norway. It was organised as an inclusive process with the active involvement of the network and a large number of experts as well as five communication groups on specific themes such as globalisation and regional change, the new concept of work, technology, the welfare state, and the financial sector.

Technology foresight activities in the private sector

Large companies such as Statoil began at the end of the 1980s to use scenarios as an integral part of their planning work (Øverland & Neumann, 2001). Private consultancy companies have also specialised in forward and future oriented

services, offering strategic advice and management to companies and organisations in the public and private sector. One example is the company Preview, one of whose consultants was involved in both the Scenario2000 project in 1987 and the follow up conference in 1999 (www.preview.as).

Several collaboration projects on the future research and innovation have been set up between the Research Council of Norway and industry. One example is the FIIN project. This collaboration between the Confederation of Norwegian Business and Industry and the various sector associations aims to strengthen research and development in companies. Another example is the "Energi 2010" project. This collaboration between the Research Council of Norway and the Federation of Norwegian Manufacturing Industry aims to improve research and development activities in the supplier industry.

4.6 Sweden

Box 4.5: Swedish Facts and Figures

Population – 8,882,792 (2001)
Area – 449,964 km2
Inhabitants/km2 – 19.6
GDP/inhabitant – 25,641$ (2000)
Important economic sectors - Mechanical industry, mineral and forest industry, ICT, chemical/pharmaceutical industry
Total R&D Expenditure / GDP – 3.80% (1999)
Government financed R&D / GDP – 0.93% (1999)
Industry financed R&D / GDP – 2.58% (1999)

Source: Nordic statistics; OECD, 2001b.

The Swedish science and technology infrastructure

The Swedish R&D system rests on two pillars: large manufacturing firms and universities. The overwhelming proportion of state-funded research is carried out at universities and university colleges that are guaranteed research resources to make them attractive partners to industry and the community at large. Swedish industrial R&D activities are, in turn, dominated by a number of large R&D-intensive multinational high and medium-high technology manufacturing groups. Even knowledge-intensive business service firms are important in this respect. The Federation of Swedish Industries serves as an important umbrella organisation promoting industrial R&D and technology foresight.

International comparison reveals that Sweden invests more than all other countries in R&D (3.8% of GDP in 1999). Company funding increased sharply throughout the 1990s. The share of public funding was 25% in 2001. Concerted efforts in high priority research fields and the facilitation of interdisciplinary research are among the issues that have been paid specific attention in the government's research policy. An important feature of Swedish research policy is, however, the "sectoral-research principle": every sector of society is supposed to assess its own needs for R&D inputs, weighting them against other needs to promote the sector's development (Burnett, 2001; Norgren et al. 2000; www.cordis.lu; www.scb.se).

The organisation for Swedish research funding was renewed in January 2001. The Swedish Research Council, which supports fundamental research in all scientific fields, plays a pivotal role in this new organisation and consists of three sub-councils: the council of liberal arts and social sciences, the council of natural sciences and technology, and the council of medicine. Together with an education committee these councils distribute funds within their own areas of responsibility. The Swedish Research Council also provides analyses of research policy and advice on research issues for the government and promotes Swedish participation in international research cooperation.

In addition, the government and Parliament have set up special research councils in two areas where the need for new knowledge is deemed to be particularly great. The Swedish Research Council for Working Life and Social Sciences promotes research relating to welfare, public health, social care, the labour market, work organisation and the work environment. It was established in 2001 through a merger of the Swedish Council for Social Research and the Swedish Council for Work Life Research (www.fas.forskning.se). The Swedish Research Council for Environment, Spatial Planning and Agricultural Sciences (FORMAS) promotes, in turn, research on sustainable development. It does so with the aim of furthering knowledge of biological natural resources, land and water, and society's sustainable exploitation. FORMAS is a governmental research-funding agency with connections to several ministries: the Ministry of Environment, the Ministry of Agriculture, the Ministry of Industry, Employment and Communications and the Ministry of Education and Science (www.formas.se).

A new authority, the Swedish Agency for Innovation Systems (VINNOVA), also became operational in January 2001. The Agency integrates research and development in technology, working life and society. It cooperates closely with private and public players, supporting needs-driven research for different types of players in society (regions, suppliers, emerging industrial clusters, etc.). It also facilitates mobility between politics, business and research. Its activities include the provision of support for R&D in technology, transport, communication, the employment sector and the labour market. The promotion of foresight was one of the tasks given to VINNOVA when it was set up (www.vinnova.se; Arnold, E. et. al. 2001). The role of the Swedish Development Agency (NUTEK) has, since VINNOVA's introduction, been to serve enterprise development and regional development, together with ALMI företagspartner. NUTEK/ALMI provides various kinds of support to enterprises, including financing, advice and information. It does so with the aim of creating new companies, supporting their growth and strengthening the regions. The organisation also encourages networking and develops knowledge and evaluation methods that can be used by enterprises and in regional development (www.nutek.se).

In addition to these basic elements of the Swedish R&D infrastructure, there are also a number of organisations that contribute to Swedish R&D and technology foresight activities. Among the most important are the Royal Swedish Academy of Sciences (IVA) and a number of foundations set up with capital from the former wage earners' funds — e.g. the Swedish Foundation for Strategic Research. IVA is an independent organisation whose overall objective is to foster the sciences and to promote the use of science in the service of society.[8]

8 IVA was founded in 1919. Among other things, it provides a forum where researchers can meet across subject borders, arranges international scientific contacts, acts as a voice of science,

The Swedish Foundation for Strategic Research supports research in natural science, engineering and medicine with the objective of promoting the development of high-quality research environments in areas of importance for the future competitiveness of the country.[9] (www.iva.se; www.stratresearch.se). Some other bodies that are of interest in this context are the Institute for Futures Studies, which promotes a futures perspective in Swedish research (www.framtidsstudier.se) and the Swedish Energy Agency, which is the central administrative authority for matters concerning the supply and use of energy and which also supports research into renewable energy sources, the procurement of energy efficient products, and investment grants intended to encourage the development of renewable energy (www.stem.se).

Swedish foresight exercises

Sweden is the only Nordic country in which a wide-ranging national-level foresight exercise has been carried out. Swedish Technology Foresight ('Teknisk framsyn') was a national project bringing together a large number of players from the knowledge community to discuss the best ways of promoting long-term interplay between technical, economic and social processes. The project was initiated and run by four organisations: the Royal Swedish Academy of Engineering Sciences (IVA), the Swedish National Board for Industrial and Technical Development (NUTEK), the Swedish Foundation for Strategic Research and the Federation of Swedish Industries. It was conducted in close cooperation with the government, companies, public agencies and other interested parties.

The Technology Foresight project aimed to create insights and visions about technological development over the long term (10 to 20 years). This, it was hoped, would help to identify worthwhile strategies in education, research and development promoting the development of Swedish society. The project had three main objectives to:

- strengthen a futures-oriented approach in companies and organisations;
- identify areas of expertise with potential for growth and renewal in Sweden;
- compile information and design processes for identifying high-priority areas in which Sweden should build expertise.

The core work was carried out by eight panels, each comprising up to 15 experts with different perspectives, and these panels were backed up by reference groups. An advisory committee composed of representatives of different organisations ensured that vital aspects of Swedish community life were integrated into the work of the project. The design of the Swedish TF was inspired by UK foresight work (excluding the Delphi approach).

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influences research policy priorities, and disseminates scientific and popular-scientific information in various forms. IVA has also played an active role in promoting broad scope, as well as more focused TF exercises in Sweden (Teknisk framsyn, Energy Foresight).

9 The Swedish Foundation for Strategic Research was established in 1994 with the capital from the former wage-earner funds. In 2000 it was financing about 70 research programmes and some 100 research projects. The forms of support included financing of strategic research centres and concentrated research efforts at universities, gender-balanced programmes for new research leaders, new orientations in strategically important areas, as well as various network programmes and graduate schools. The foundation was also one of the promoters and financiers of the broad-scope Swedish foresight exercise (Teknisk framsyn). The capital of the foundation is planned to be used up by year 2020.

The Swedish Technology Foresight started in 1998, the kick-off of the panel work was in January 1999, the reports of the eight panels together with a synthesis report were published at the beginning of the year 2000, and the exercise was concluded by a conference in March the same year. The reports described driving forces, trends and expected developments in the selected areas, and some of them also proposed recommendations for action. One of the essential messages of the project was that Technology Foresight cannot predict the future, but it can improve preparedness for future developments and influence investments in the production and dissemination of knowledge. The process of creating and conducting a futures-oriented project of this type was considered to be, in itself, as important as the final assessment of technological developments. During the years 2000 and 2001, more than twenty regional conferences were organised around Sweden. The findings of the project have been disseminated via the four support organisations and by panel members on more than 100 occasions.

The cost of Swedish Technology Foresight (SEK 34,500,000) was met by the Swedish Foundation for Strategic Research, the Swedish National Board for Industrial and Technical Development (NUTEK), and the Swedish Government Offices.

Lessons learned from the Swedish national-level TF have been described in an evaluation report. It would appear that the following comments should be borne in mind in the planning of Nordic TF exercises:

- The participants appreciated the focus on the longer term and on change. Industry people, especially, felt that it was good to focus on a longer-term development instead of adopting the short-term view normally taken in business.
- The Swedish TF tried to avoid too narrow a technological focus, emphasising the broader societal perspective. According to some evaluators, this perspective was introduced too successfully in the sense that some panels lost the technological perspective.
- A number of TF participants also applied the resulting knowledge in practice. For instance, the results of the Swedish TF have been used at regional and micro levels when the participants have applied the knowledge in their own tasks. In general, practical implementation of the TF results would need further attention, however. It is also obvious that the success of the TF, and the usefulness of the knowledge generated, depends on the participants and their involvement. Special attention should thus be paid to the selection and motivation of the participants.
- The Swedish TF had a very tight time schedule. The panels were started up before being fully appointed and before the chairman and project leader/facilitator were properly introduced to the overall project and process. The anticipated workload was half-time, but in reality the workload was much bigger, and the identification of key areas, as well as the writing of the reports, took up considerable time. If a major part of the writing work would be delegated to professional writers and/or consultants, the panels could concentrate on generating ideas. This would also facilitate broader mobilisation.
- Four basic scenarios were developed to support the TF process. However, in many panels the subsequent scenario process functioned as a check of the strategy instead of outlining various plausible futures. Specific attention should thus be paid to the provision of appropriate support during work with the scenarios in the TF process.

VINNOVA has recently taken on an initiative to set up a new round of technology foresight in Sweden. Formal agreement to proceed with this was reached in June 2002.

In addition to this national-level foresight exercise, some sector-specific and territorial foresight projects have recently been carried out or are currently in progress in Sweden. Examples of these are the energy sector foresight coordinated by The Royal Swedish Academy of Sciences (IVA) and the territorial foresight exercise in western Sweden.

The energy sector foresight looks at the Swedish energy system in both a European and global context, with emphasis on the European dimension. The project will focus on the next 10–20 years, with a brief look at scenarios for the next 50 years. A holistic approach is being applied in this project too. The objectives of the Energy Foresight are to:

- initiate an in-depth discussion of energy systems and energy-related activities in industry and society;
- create insight into and visions of developments in the energy field in Sweden with an emphasis on international aspects;
- help the different players in the energy field understand and learn from each other, and to illustrate how developments in this field take place in interaction with other sectors of society;
- demonstrate how different future scenarios described in the Energy Foresight project should affect education and R&D with a view to improving the preparedness, and enhancing the competitiveness, of Swedish industry;
- provide a sound, well-informed basis for discussion of opportunities and obstacles to sustainable development in Sweden.

The Energy Foresight project was started in 2001/2002 and will be completed during the first half of 2003. The project is headed by a steering group appointed by the President of IVA, and a Senior Project Manager appointed by the steering group. Many of the project's activities will be carried out by four panels, each commissioned to study a particular field. Concurrently with the panel work, a series of popular, factual reports will be produced in order to provide basic data for the panels' use. A number of seminars will be arranged in order to acquire in-depth knowledge and new perspectives in selected areas. The work of the panels will result in reports summarising the findings.

The territorial foresight exercise in western Sweden started with a series of seminars organised by key-actors which contributed to regional developments (Chalmers, Gothenburg University and other educational institutes, companies and industrial associations, public service organisations, etc.). The topics of the seminars included societal infrastructure, knowledge and welfare, technology and health, future services (electronic and of other kinds), future production systems, future materials and future food. On the basis of these seminars nine theme areas with specific development needs were identified. A working group consisting of regional key-actors has been established to maintain the process.

4.7 Cross-border cooperation in the Nordic countries

Along the internal borders in the Nordic countries, as well as along the external borders with neighbouring countries, local authorities often work together with private companies and associations to initiate and consolidate links with partners on the other side of the border.

The Nordic Convention of 1977 between Denmark, Finland, Norway, and Sweden was one of the first inter-state agreements in which sub-national authorities were given the competence to conduct activities with partners in other countries. In the shadow of the Nordic inter-governmental cooperation activities on a joint labour market, a passport union, and cultural and educational cooperation, local and regional authorities started to increase cooperation across the border regarding important aspects of daily life, including cultural affairs, the environment, health, communication and tourism. The Oresund Committee was founded in 1964 to adjust planning issues relating to one or more fixed links across the belt dividing Denmark and Sweden. Another example is the Nordkalotten between Norway, Sweden and Finland, in which local and regional authorities have worked together in areas such as tourism, emergency, sewage and planning.

Over the course of time, different forms of political, administrative and economic cooperation have been initiated and consolidated across internal and external borders in the Nordic knowledge region. These include inter alia the Oresund Region, which is regarded as an example of a cross-border learning region in which government, academia and industry build networks in different economic sectors, including life sciences, food, and the environment (see e.g. Maskell & Törnqvist, 1999; www.oresund.com). Another, recent example is the newly founded Scan-Balt cooperation. This is a Scandinavian and Baltic platform for research, education, public services and innovation within biotechnology and related technologies in which different stakeholders from government, academia and industry from the Nordic and Baltic Sea areas create and build clusters and strategic collaborations and networks (see www.mva.org).

In the complex conditions obtaining in border regions, foresight methods offer an open-ended strategic process that brings together people and systems across the national border and institutional boundaries (Joergensen, 1999 and 2001b). Such regional foresight can be instrumental in building a cross-border learning region of the kind sketched in the following description of the STRING region.

The STRING experience

In regions around the south-western part of the Baltic Sea a diverse group of regional authorities have recently concluded a two-and-a-half-year strategy process on how to jointly create a sustainable basis for growth and development in an increasingly globalised world. This project is called the STRING project, and the strategy process it involves has been guided by a regional foresight approach to ensure that the articulation, execution and exploitation of the joint efforts were coordinated across three national borders.

The STRING project is about building bridges — in the sense both of physical constructions across the sea and social constructions across institutional and spatial boundaries. The overall aim is to create a STRING of interrelated and

dynamic urban and rural locations including towns, cities and villages. The idea of the STRING project is thus to reach a critical mass by building bridges in order to cope with future changes in society on a regional, European and even global level. As for the physical bridges, the project has kept alive the political debate on the "missing" link across the Femer Belt — a link that will complete the so-called Scandinavian link from Sweden over Denmark to Germany. As for the social construction, the project has brought people and systems together across three national borders within a long-term strategic cooperation framework.

Figure 3: Map of the STRING Area

Source: STRING, 2001.

The *outcome* of the strategic process has been (and more generally can be) the development of a common vision and strategic action plan comprising a number of strategic action fields, such as business development, education, infrastructure, and culture. Equally, a number of concrete projects — so-called lighthouse projects — offer useful tests and illustrations of the ambitions of the project. As the project builds on existing collaborations and networks, these latter collaborations are given new meaning. Through the involvement of a wide range of experts throughout the process, new networks are established and new opportunities are created.

The *management structure* has been lean, transparent and effective, consisting of the monitoring of activities, a steering level to secure continuous coherence between goals and activities, and a virtual project secretariat made up of officials from the STRING partners.

Experience drawn from other cross-border cooperation activities in the region is useful in highlighting the sensitivity of the border and the need to take the time necessary to develop a common language and to give meaning to common

visions and action plans. Classical foresight characteristics involved in projects of the kind discussed here include:

- Expert panels with more than 100 members from industry, academia and government coming from the area involved in an open strategy process chaired by progress officials.
- Concentration on the longer run (2000-2010) and the use of scenario building to develop various plausible future developments in the example discussed here. Driving forces were identified and four scenarios were developed in workshops and further framed by consultants.
- Communication between participants can be facilitated by reports and discussion papers produced by external consultants, some of which could reflect dialogue with the participants more closely.
- The coordination of the scenarios, visions and action plans can be provided by project management and workshop chairmen, but should always be carried out in accordance with the consensus achieved in earlier stages of the project.
- Commitment is steadily built up throughout the process (e.g. in this case from the initial project application for INTERREG IIC funds) through the various workshop meetings, the political forums and public conferences. In the end broad support should make it possible to embark on concrete projects within strategic action fields that give shape to the vision of a high quality area based on innovation, entrepreneurship and sustainability.
- Most importantly, democratic legitimacy can be built up by linking each step of the foresight process to the democratic institutions of the various regional authorities. Dynamic political forums can be usefully established in which political representatives can meet and give direction to the project. In the STRING example, the aim was not to build new, formal cross-border cooperation structures of the type seen, but to align existing structures in new, flexible and transparent ways. The challenge is to bring the cooperation exercise closer to the citizens of the region. In the example, a political commitment was made to involve citizens in future activities, such as participatory projects, and thereby enable democratic expression across borders and boundaries.

In conclusion, the *future boundaries* of cooperative exercises such as STRING are constituted by the ability of their founders to consolidate existing cooperation, to assure democratic legitimacy and to create new bridges with neighbours (which may in turn imply further foresight processes).

The above regional foresight exercise was intended to develop a comprehensive strategy for the region covering a number of relatively broad action fields. More technology-oriented foresight exercises may also be conducted across national boundaries in order both to build synergy and achieve critical mass in connection with specific themes or sectors.

4.8 Overview of technology foresight activities in the Nordic countries

The table below presents an overview of the key players and their activities within technology foresight or related activities in the five Nordic countries.

Table 1: Overview of TF activities in the Nordic countries

	Denmark	Finland	Iceland	Norway	Sweden
Government	Ministry of Science, Technology and Innovation: 4 year pilot project with sectorial TF Danish energy Authority: Strategic energy analysis and action plans Danish Board of Technology: TA challenges embedded in broad consultations	Ministry of Trade and Industry: pilot study 'On the Road to Technology Vision', TF needs assessment, 4 year TF development project started in autumn 2001 Tekes, Academy of Finland, Sitra: co-funding of TF studies and outlooks, internal vision and strategy processes Parliament of Finland, Committee for the Future: TA studies on various topics (come close to TF studies) TE-Centres: series of TF seminars, regional foresight	Ministry of Industry and Commerce: Short term development plans within innovation, regional development etc. Research Council: Short term strategies for R&D IceTec: Pragmatic prioritisation	Ministry of Labour/government adm.: Norway 2030 Research Council of Norway: Short term R&D prioritisation. Strong or weak arena for R&D? Norwegian Defence Research: Strategic analysis and foresight. Board of Technology: TA challenges and possibilities	Swedish National Board of Industrial and Technical Development (former NUTEK) and the Swedish Government Offices co-financed the broad scope TF exercise 'Teknisk framsyn' in 1998-2000. The role of Swedish Energy Agency in the on-going energy foresight? Public service organisations being involved in the regional foresight exercise in Western Sweden
Academia	Risoe: Research and development within TF, sectorial TFs DTU: Foresight network and advisory tasks RDSP: Delphi and scenarios	VTT: sectoral TF studies, international cooperation in TF monitoring&research Finland Futures Research Centre/ Turku School of Economics: broad scope and sectoral foresight studies, scenario and vision seminars, research	University of Iceland/spin-off companies: the future hydrogen society	STEP group: Limited future activities SINTEF group: Sectorial TF hydrogen energy	The Royal Swedish Academy of Sciences (IVA) was one of the key-actors initiating and carrying out the broad scope TF exercise 'Teknisk framsyn' IVA initiator and key-actor of the on-going Energy Foresight project

		and development of TF methodologies Systems Anal. Laboratory/Helsinki Univ. of Technology: research on TF methods and practices IAMSR/Abo Academy: scenario and vision work in co-operation with companies, industrial federations			University researchers participated in the processes of the broad scope TF 'Teknisk framsyn' and its evaluation Universities and educational institutes being involved in the regional foresight exercise in Western Sweden
Private sector	Danish Industry: Strategic analysis and pilot project on TF and SMEs Society of Danish Engineers: TF within energy systems Institute for futures Studies: Future seminars and consultancy	Industrial federations: sector and technology specific TF studies, industrial strategy processes etc. ETLA: Cluster studies, incl. TF. Finnish Association of Graduate Engineers (TEK): Round-table TF exercises, 'Future Engineer' project etc. Private consultants: TFs, Delphi, study of National-level TF exercises	Icelandic Industries: vision seminars and Forums of Technology	ECON center: Horisont 21	Federation of Swedish Industries one of the key-actors initiating and carrying out the broad scope TF exercise 'Teknisk framsyn', industry representatives participated in the TF process Companies and industrial associations being involved in the regional foresight exercise in Western Sweden

5 The potential of Nordic technology foresight activities

5.1 The prospects of a Nordic technology foresight

Technology foresight activities make a valuable contribution to the development of research and innovation policies and other activities essential for the success of integrated strategies for economic and social development. They can improve policy-making across a broad range of policy areas and at various levels (local, regional, national, and international), ranging from single industries to specific technologies straddling various sectors. However, technology foresight activities have not yet been developed and implemented systematically in the Nordic and neighbouring countries. Nor are the relevant actors presently networked and profiting from each other's experience to the necessary extent.

In the previous chapter, the technology foresight activities of individual Nordic countries were briefly reviewed. In this chapter, the prospects of common Nordic technology foresight activities are examined. The results presented here summarise views presented by national-level and Nordic experts who contributed to this study (a list of experts is given in Appendix 1). The questions put to the experts concerned national systems of science and technology as well as the prospects for technology foresight at Nordic level. The experts were first sent information about the background of the study and the basic research questions by e-mail (see Appendix 2). They were then given an opportunity to contribute through a personal interview, in group discussions, or by individual e-mail correspondence (depending on their schedules and preferences). The information was collected between September, 2001 and May, 2002. Respondents also reviewed and commented the draft version of this report.

In total, 31 respondents with expertise in the areas of technology foresight and Nordic co-operation contributed to the study by offering information and viewpoints. The results drawn from their contributions are presented under the following headings:

- The rationale for Nordic technology foresight activities
- Potentials and concerns of Nordic technology foresight cooperation
- Sectors or technologies to be focused on in a Nordic technology foresight
- Institutions to be involved and served

Finally, the findings are summarised, and the prospects for a Nordic technology foresight are set out.

5.2 The rationale for Nordic TF activities

A common view among the Nordic interviewees is that the Nordic perspective will be fruitful because of our common history, culture and views on sustainable development. Although the importance of European R&D co-operation has increased, there is apparently a need to coordinate efforts in order to get the Nordic viewpoints represented at a European level. Joint efforts in the field of technology foresight could be helpful in this respect. Nordic countries are also

front-runners in important technological fields, such as ICT and biotechnology. Well organised foresight processes could also increase the role of Nordic countries in shaping European and international norms.

It was emphasised, however, that the tacit rationale of a Nordic technology foresight exercise should be examined more closely. The basic question is what kind of technology foresight themes and issues can be handled at the Nordic level, rather than at the level of individual Nordic countries. Other important questions are, for instance: Which Nordic organisations might benefit from a joint Nordic technology foresight? and What long-term technology-related developments and issues would the Nordic policy-makers and planners like to see clarified?

Instead of an action-oriented or policy-oriented approach, a more exploratory approach could perhaps be taken. The main question would then be: What technology-related developments will shape the future of Nordic cooperation in various fields (e.g. by creating new needs, new possibilities or new limitations)? Experts from other countries could also be invited to participate in Nordic TF processes (as workshop participants and reviewers etc.) so that closed Nordic discussion forums do not develop.

Further statements highlight the need to build a critical mass and to position Nordic science and technology in a wider international context. The following viewpoints were presented by national-level and Nordic experts:

- **Nordic benefit** [Nordisk nytte] should not be limited to internal Nordic interests. Rather, it should be integrated in a Nordic vision which is externally oriented towards the global context and those markets in which there are concerted Nordic strengths.
- The Nordic countries should **create research and development synergy** in those sectors where they together have comparative advantages. This may include resource-demanding research fields, such as biotechnology, or highly developed welfare technologies, such as medical devices, medical care, environmental/green technologies and other welfare state services.
- Technology foresight should **strengthen existing and new networks of excellence** among Nordic partners and at the same time position them in the larger international research and development landscape, including Nordic funds and the Research Framework programme of the EU. Nordic networks are members of the wider European research network. This may indicate that Nordic cooperation is one way to position Nordic institutions in the larger European research and technology networks. This is also the case for ongoing Nordic activities among technological service institutes and neighbouring organisations, and this may call for a more systematic process of looking into the long-term future of science, technology, the economy and society with the aim of identifying areas of strategic innovation.
- Nordic technology foresight might **identify hidden competencies and research areas** which could benefit from further cooperation in the Nordic knowledge region.
- **Good reasons** must always be found for undertaking technology foresight at an international level. But the discovery of good reasons for a Nordic technology foresight might not be a straightforward matter. Therefore, a Nordic technology foresight should have a clearly stated goal. This may also be the case for more specific technology foresight work — e.g. within technology areas or among specific research and technology institutions. The problems which would be encountered are the same as in a national

technology foresight but in some ways more difficult to solve (developing the right institutional framework, agreeing on subject areas and on the selection of panellists if the panel method is chosen, and achieving a reasonable level of success in the implementation phase).

- **The ideal Nordic technology foresight** will be well integrated with the foresight exercises of each country and indeed supportive of them. High-level visibility should be aimed for, although very extensive exercises starting from scratch should be avoided. In general, foresight exercises should help us to understand the possibilities of developing technologies in terms of future applications in business and society. In particular, they should help with the identification of any future threats, problems and opportunities that call for action. The foresight exercises should also clarify the role of technology development in finding solutions to perceived problems. Foresight exercises should contribute to the creation of common visions concerning technological developments and their business/society applications. They should also help to coordinate policies with the help of which these visions can be realised. On the other hand, it is important to raise public awareness of future-related questions about technological developments, since one important task of foresight exercises is to promote public debate on future developments, including the role of technology in these developments. The combination of technology foresight activities with parliamentary technology assessment activities could also be considered.
- The **timing** of a Nordic foresight is important. It is apparently a suitable time to start a Nordic exercise now. There have recently been a number of national-level activities in the field of technology foresight. These include national-level/territorial/sectorial technology foresight projects, needs assessment, and workshops, seminars and conferences organised by the key actors in each country and also in the context of European cooperation. This could thus be the right moment to wire in Nordic cooperation in this field.
- To keep the Nordic-level technology foresight processes compact, they should apparently be **driven by experts and professionals**. To guarantee fluent communication between the experts, the **language** of a joint exercise should be English. This would also facilitate the exchange of ideas and resulting knowledge in wider international forums. Invitations to experts in other countries to participate in workshops and act as report reviewers could also be made straightforwardly. On the other hand, sharing the knowledge and obtaining commitment at the national level would require processes in which members of the wider public are allowed to communicate using their own languages.
- Nordic technology foresight should **build on existing international and national-level technology foresight experiences and results**, and it should add its own values in order to stimulate common efforts within research and innovation activities in the Nordic countries.
- In order to avoid redundancy and the reduplication of work in the same sort of information gathering, it might be better to pursue Nordic cooperation within activity fields in which economies of scale or scope can be produced — for example, in **technology radar, bibliographic overview etc.** — rather than carry out complete Nordic technology foresight exercises.

The cross-border perspective is highlighted by various interviewees as a promising field for technology foresight collaboration on a more limited scale, e.g. the Øresund Region, the North Calotte Region, and the recent ScanBalt biotechnology initiative. In particular, the following two viewpoints were taken up:

- A cross-border technology foresight could, for example, focus on structure or framework conditions, and less on technology in order to analyse and **strengthen possible knowledge synergies** between universities and public and private institutions.
- In border regions there are still barriers to the mobility of people. Transport costs are high, the recognition of qualifications is still problematic, and there is a shortage of qualified personnel within certain sectors. A Nordic cross-border technology foresight could **strengthen the framework conditions and visibility** of the region and thereby contribute to the competitive advantage of local companies as well as attracting foreign investment.

The experts consulted express quite diverse expectations about how experiences of technology foresight methodologies and results and learning are exchanged. This primarily reflects different positions on how knowledge about technology foresight practitioners is best diffused. Is knowledge best diffused organically through Nordic technology foresight exercises, or is it a question of building intermediate exchange structures that assure a proper exchange of experience and knowledge sharing? The following viewpoints were highlighted by the experts contributing to the study:

- A Nordic technology foresight would provide an opportunity to **exchange ideas and experience** relating both to technology foresight processes, methodologies and possible ways of making use of the resulting knowledge. Joint exercises would also facilitate cross-border networking around future-oriented technology issues. Experiences from the Nordic technology foresight (process, methods, etc.) would be useful in developing national-level practices. For this reason it would be important for there to be a mechanism that would allow the various parties involved in the development of technology foresight in respective countries to follow and discuss the process as it proceeds.
- The most valuable contribution would perhaps not be the Nordic technology foresight per se, but rather an **organised, continuing exchange of technology foresight experiences and plans** among the Nordic countries. After all, technology foresight is still a relatively experimental activity, and a broad sharing of the learning experiences will probably make it more effective. A joint Nordic technology foresight could also serve as a catalyst: it could trigger and promote an exchange of ideas and views, and in this way enhance the exploitation of possible synergies.
- Cooperation at Nordic level should only focus on the **exchange of experiences** relating to results and methods from national activities.

5.3 Potentials and concerns of Nordic technology foresight collaboration

The potentials of Nordic technology foresight activities are thought, primarily, to derive from our common history, shared values, democratic heritage and governance structures and geographical proximity. The Nordic countries also have shared concerns regarding the need for international trade. Furthermore, there is a long tradition of collaboration between Nordic organisations. The somewhat doubtful concerns are, in turn, related to the highly diverse economic structures of the Nordic countries as well as to the differences in management

and communication styles. Likewise, a Nordic technology foresight might not be the right level to influence the political agenda and decision-making.

The following potentials were listed by the experts consulted:

- **Geographical proximity and shared values**: the Nordic countries are all located in Northern Europe, and their societal and value systems (as reflected in welfare, sustainable developments, democracy, equal rights) are similar.
- **Exchange of experience in technology foresight activities**: it might be useful for the Nordic countries to learn from each others' approaches and experiences in carrying out foresight/forward-thinking exercises. Focused foresight exercises in newly emerging fields — problem-solving and innovation oriented, as well as 'technology push' exercises — might be fruitful if issues and areas of common interest can be identified.
- Nordic technology foresight may **broaden the expert base** and contribute to better cross-institutional learning on foresight practises. With the help of TF co-operation, Nordic viewpoints may also attain the critical mass that is needed to promote important issues in European and global contexts.

On the other hand, the following doubts were presented:

- Despite common history and geographical proximity, the Nordic countries are **quite different** where, for instance, natural resources, industrial structure, technological orientation and managerial cultures are considered. It is therefore a far from straightforward matter to identify areas of common interest for a technology foresight.
- **Loss of cultural specificity:** when working at Nordic level there might be a loss of familiarity with local processes (the idea that the bigger the unit, the more elitist the process) and it is not easy to define who is the "Nordic target group" for such processes.
- **Too narrow a focus and loss of international expertise** are also mentioned as a possible weakness of a Nordic technology foresight. On the other hand, this might be compensated for by involving experts from industry and research outside the Nordic countries.
- As conditions for sustained technology foresight tend to be better at lower levels, the question is whether practical orientation and concrete contribution can be found at a Nordic level. There is, then, a risk that a Nordic technology foresight will become **too academic**. Furthermore, the Nordic countries nowadays see themselves as part of the EU or in an even wider international/global context. Interest in using a Nordic framework may have diminished to some extent.
- The conclusions of a technology foresight should be tailored closely to the primary political agenda. A strong incentive for expert participation is provided by the need to have an impact on political decision-making. However, the Nordic level is **not considered a strong political arena for technology foresight**. Therefore technology foresight exercises are better conducted at European or national levels.
- Technology foresight at the Nordic level **raises the expectation** that there will be sufficient R&D resources to realise and implement prioritised action fields and activities. The resources directed to Nordic co-operation are, however, quite limited, and during the past decade they have been decreasing rather than increasing: European and international co-operation has been stressed instead. New types of thinking would be needed to

identify opportunities for Nordic co-operation in the changing world. The need to build a critical mass for shaping the global developments has already been understood, but as yet it is not very well reflected in the structures supporting this type of co-operation.

5.4 Focus of Nordic technology foresight activities

When the rationale for Nordic technology foresight is combined with the above mentioned potentials and concerns it becomes interesting to ask both what kind of scope, sectors and technologies Nordic technology foresight activities should involve and what actors should be included. All the Nordic countries are small, advanced and industrialised (or post-industrialised), but important structural differences remain, and these make it difficult to arrive at focal sectors that would suit all. The following issues were highlighted by the experts who contributed to the study:

- Nordic countries have a **common strength** in the development and/or application of ICT, partly as a result of an early commitment to a shared Nordic standard (NMT). A joint technology foresight could perhaps be designed with a view to maintaining that strength.
- The design of a technology foresight exercise need not, however, necessarily entail the pre-specification of focal technologies. **Relevant problem areas**, such as health, sustainable production (and green technologies in general), sustainable energy systems and so on may be defined instead. Although the obvious answer is to select technologies and sectors where the Nordic countries clearly have common interests for reasons of geography, size, climate, industrial structure etc., the identification of technology foresight exercises in which those interests would perfectly meet is a far from straightforward matter. A general recommendation, however, might be to **start with one or just a few subject areas**. A technology foresight exercise on hydrogen energy might be worth considering, since this is an area where several Nordic countries are already active, but still rather confused about the future. Biotechnology and information and communication technologies (ICT) might be less fruitful areas to start with as developments in these fields are considered in various other forums where Nordic key actors are actively involved .
- Other focal areas might include sectors that are **embryonic but have huge potential**, or, alternatively, **old traditional sectors**. In the latter case, the aim would be to examine ways of integrating the ‘new’ and ‘old’ economy/technology.
- It would be advantageous to choose business areas and technologies where the Nordic countries can better proceed with cooperation than by competing in global markets. **Areas that could open up cooperative possibilities** in technology development by building on strengths of each party and creating new kinds of combinations would be of particular interest. Nordic countries have, for instance, similar backgrounds and interests in developing welfare services. Although this theme is not ‘technological’ by definition, it has a technological aspect (as becomes apparent when one considers the role of ICT technologies in supporting medical self-care). It should thus be considered as a potential cooperation field.
- Parts of the Nordic countries are sparsely populated, isolated or characterised by extreme climate conditions (Greenland, Lapland etc.). These **features of small isolated communities** may be the focus of Nordic

TFs in areas such as medicine, housing, green technologies (waste, sewage), ICT etc.

- The following are some possible examples of technologies that have **significant future promise from the viewpoint of both business and society**: electronic industries/information and communication technology, functional food, technologies for ageing society, health, biotechnology, nanotechnology, the energy sector, excess heat and the hydrogen society and green/environmental technologies.

After defining the focus of the technology foresight exercise, it is important to identify influential actors in the field, and to encourage their involvement in the TF process.

5.5 Institutions to be involved and served

The question which institutions are to be involved and served is one of the key issues in technology foresight — where the ambition at the national level is always to include as many **stakeholders** as possible in order to facilitate the implementation process. These stakeholders include the users, producers and developers of technology. Consequently, it seems that a mixture of different players (including research and development institutions, industrial associations/federations, financiers and technological service institutes, companies and the wider public) should be involved.

The **political system** — that is, parliaments and the institutions serving the parliaments' information needs — could be mobilised too. However, the need for wide variety in the participants' backgrounds might be an obstacle in getting some concrete results here. Participants should thus be selected on the basis of the aim and content of the technology foresight exercise. On the other hand, the same types of participant should be involved in each country. According to many experts with experience of national-level foresight exercises, the process and the networks are even more important than the resulting reports.

In a multinational technology foresight the inclusion of too many stakeholders might create managerial problems. This is definitely a problem, so some kind of limitation must be imposed. The selection of institutions would then depend on the subject area. Given a particular theme, or set of themes, one should try to involve and interlink all relevant actors/institutions so that the innovation system is "wired up". Relevant combinations will depend on what kinds of technology foresight themes or issues are in focus.

To ensure that an international outlook is adopted in the exercise, **international experts** from industry and science should be involved, as speakers and participants in workshops and conferences, as respondents in Delphi, as reviewers of results and so on.

Finally, the question what institutions are to be served should not be confined to stakeholders in the national systems of innovations and the national political system. It is also necessary to ask: What **Nordic organisations** might benefit from a joint Nordic technology foresight? In addition to the institutions directly linked to this study (i.e. the Nordic Council of Ministers of Education and Research, the Nordic Industrial Fund, the Nordic Science Policy Council), there might be other potential winners. These might include the Nordic Council on Disability Policy, Nordic ESB-coordination (environmental specimen banking),

Nordtest, the Nordic Society for Space Research, Scandinavian Institute of Dental Products (NIOM), and the Nordic Health Technology Forum.

5.6 Summary

The *rationale* for Nordic technology foresight activities rests first and foremost on the common values created through a common history and culture and well consolidated Nordic collaboration and contributes to developing a common knowledge region. Some interviewees do not recommend a Nordic technology foresight, either because they consider it to be better conducted at national or European level, or because they consider the Nordic level too weak and without political influence.

If well conducted a Nordic technology foresight would:

- Create research and development synergy in promising and resource-demanding areas.
- Strengthen existing and new networks of excellence — something which is important in an international setting and particularly within the EU.
- Build both momentum in the complex array of technology foresight activities and the multiplicity of institutions and networks.
- Add Nordic value to international technology foresight results.
- Avoid redundancy in information gathering activities such as technology radar and bibliometric overviews.
- Strengthen knowledge synergies, framework conditions and visibility in cross-border regions.
- Ensure that there is an exchange of experiences and learning among technology foresight practitioners in the Nordic countries.

The positive potential of Nordic TF cooperation thus relates to:

- Geographical proximity and shared values
- Exchange of experience and learning
- Economies of scale and scope

Doubts are, by contrast, connected with the following issues:

- Nordic countries are quite different
- Loss of cultural and local specificity
- Too academic and distant from reality and where decisions are taken
- The Nordic level is not considered a strong political arena
- Raises unrealistic or false expectations about research and development funds available for Nordic cooperation

Nevertheless, there are many suggestions about the *focal areas* on which a possible Nordic technology foresight should be targeted. It is also suggested that cooperation should start with one or just a few areas in order to develop some experience and knowledge of how to conduct technology foresight in an international setting. These include:

- Relevant problem areas and areas with future promise for both business and society, such as health, sustainable energy systems, ICT, food etc.
- Embryonic areas with huge potential

- New perspectives on traditional areas
- Areas that open up collaboration possibilities in technology development, such as ICT in supporting medical self care.

Just which *institutions* are to be involved and served depends on the objectives and scope of the technology foresight. It is important to involve all relevant stakeholders in the exercise in order to facilitate networking, learning and implementation. Representatives from the political system may be included as well. In a Nordic technology foresight exercise the challenge is to balance and manage the number and diversity of participants without losing the exercise's focus. Leading international experts should also be consulted in the process in order to draw on international information and benchmarks.

6 Conclusion and recommendations

In the globalised knowledge economy, with increased industrial and economic competition, intense pressure is put on companies to be adaptable and innovative. Private and public decision-makers must cope with rapid technological developments by anticipating new opportunities and threats. This has intensified the search for proper tools for creating strategic intelligence in decision-making systems. In this context technology foresight exercises are regarded as effective tools for "wiring up" the innovation system.

Building on international definitions and experiences, we define Nordic technology foresight exercises as *systematic, future-oriented interaction processes contributing to shared visions (or frames of reference) concerning long-term technological developments. In the technology foresight exercises, technological developments — together with their prerequisites and impacts — are examined in their real-world, economic and societal context, with attention to a wide pool of knowledge and the viewpoints of various interest groups (including academia, industry and government). The processes can be broad-scope or more focused. The purpose is to facilitate communication between the interest groups and to increase decision-makers' and key actors' knowledge base, so that desirable technological developments can be supported with relevant Nordic strategies, decisions and actions. Both analyses and interaction are important in this respect.* We also assume that Nordic technology foresight exercises — as defined above — would contribute to the strategic intelligence of Nordic cooperation and decision-making.

The Nordic countries have a long tradition of cooperation within research, education, and innovation. This cooperation takes advantage of shared values inherent in the democratic and economic institutions of our welfare states. Still, there is room to create Nordic benefit and thereby add value to activities that can be solved at Nordic level or that contribute to global developments that are considered desirable and worth promoting by the Nordic countries. Here a Nordic technology foresight may be a promising tool in strengthening the Nordic knowledge region — internally, by building critical masses within selected areas of strategic importance to the Nordic region, and externally, by positioning common Nordic actions and alliances in a broader international context. By increasing Nordic competence and competitiveness, and by creating critical mass behind specific proposals, a Nordic technology foresight may act

as a *gear change* between national research and development activities and the larger European research system within Nordic priority areas.

In the Nordic countries governmental institutions, academia and private institutions have embarked on technology foresight activities, although with mixed intensity and speeds. While Sweden has recently conducted a broad-scope nationwide technology foresight exercise, Denmark and Finland have been actively searching for more diversified alternatives, building on a variety of more focused foresight exercises. A number of professional institutions, such as the Danish Society of Engineers, the Swedish IVA and the Finnish TEK, are also conducting technology foresight activities in order to influence agenda-setting in the political arena and, internally, to develop the organisation itself. Norway and Iceland have, in turn, adopted a relatively passive role in promoting technology foresight as a specific field of activity (although some features of technology foresight can be found in these countries in activities with other labels). We can also find a number of Nordic practitioners and researchers who specialise in technology foresight (at least, in Denmark, Sweden and Finland). Furthermore, the role and nature of technology assessment institutions in the Nordic countries seem to have evolved in recent years. The focus was once primarily on the controversial impacts of technologies. Now it includies opportunities created by technologies in the development of the welfare system. A demanding national-level or Nordic home market for technology foresight exercises has not yet developed, however.

The objectives of various technology foresight activities in the Nordic countries are mostly tied to the overall aim of contributing to the coherence and efficiency of the innovations system and at enhancing the anticipatory intelligence of the developers, users and producers of science and technology. To a lesser extent technology foresight activities focus on priority-setting within science and technology. Only recently, this discussion has been raised in, for example, Norway, where the evaluation of the Research Council of Norway gave rise to reflection on the question how technology foresight might help the Council to develop into an arena for exploration and have a much more proactive role in prescribing actions. With the new and strengthened Danish Ministry of Science, Technology and Innovation the coupling between science and innovation has been established, but the bridging role of the technology foresight unit at the Ministry remains to be seen. In Finland too the role of technology foresight in priority setting has been recently discussed by the foresight expert group of the Ministry of Trade and Industry and by organisations funding research (Academy of Finland, Tekes and Sitra).

The *rationale* for Nordic technology foresight activities rests on the common values created through a common history and culture and a well consolidated Nordic collaboration within research and innovation. Joint-efforts in the field of technology foresight could strengthen the development of a common knowledge region. The aims could include the creation of research and development synergy in promising and resource-demanding areas, the addition of Nordic value to international technology foresight results, the utilisation of economies of scope and scale in information gathering and analysis, and purposeful networking. The rationales also include cross-border cooperation along internal and external Nordic borders as a bottom-up contribution to the Nordic knowledge region. The *potentials* of a Nordic technology foresight are closely connected with spatial proximity and shared values, as well as with a willingness to exchange experience and to learn from each other. On the other hand, the *doubtful concerns* due to the economic and social differences among

the Nordic countries are also listed. A Nordic technology foresight exercise may also remain a distant academic exercise if proper links to political and economic decisions cannot be made. In these circumstances it is hard to justify a comprehensive Nordic joint-effort in technology foresight. Instead, it would be more reasonable to conduct technology foresight in challenging problem areas relating to the Nordic welfare states and/or with future promise for both industry and society, and to put special emphasis in improving learning and exchange of experience.

A technology foresight exercise might serve different institutions of the innovation system and the society at large at the same time:

- At the *operating level of the innovation system*, the aim is to increase connectivity and efficiency of the innovation systems in the Nordic countries. Here the key players are first and foremost: the developers, users and producers of technology of the various Nordic countries.
- At the *policy framework level of the innovation system*, the aim is to encourage strategic input to decision-making about Nordic research, innovation and business development priorities. Here, key players include political and administrative stakeholders from the Nordic institutions — first and foremost, the Nordic Council and Nordic council for Ministers, but also Nordic institutions such as the Industrial Fund and the Nordic Research Policy Council. By pointing out areas of common interest, these institutions can influence national-level decisions too. (This level did not receive much attention by interviewees.)
- At *level of civil society*, the aim is to create shared awareness of future technologies, opportunities and strategies, and to identify robust technologies that support desirable developments. On the one hand, the aim is to ensure that there is sensitivity to local demands and requirements. On the other hand, it is to create a forum for discussing controversial technological developments. A broad range of societal players are here concerned, including government, consumer and user groups, environmental groups, and community and citizens groups, as well as industry and academia.

To conclude: a Nordic technology foresight need not start from scratch. Instead it should build on historical and cultural ties among the Nordic countries and a well consolidated Nordic cooperation. Here a Nordic technology foresight may be a promising tool in strengthening a Nordic knowledge region — internally, by building critical masses within selected areas of strategic importance to the Nordic region, and externally, by positioning common Nordic actions and alliances in a broader international context.

Recommendations

On the basis of this report, the following recommendations for launching Nordic cooperation in the field of technology foresight can be made.

The establishment of a Nordic forum for technology foresight practitioners and researchers

There is some, albeit highly divergent, experience in the Nordic countries regarding the scope and focus of technology foresight. A Nordic forum for technology foresight practitioners and researchers would facilitate the exchange of experience and learning, taking into consideration common Nordic values that include a tradition of transparency, public hearings, well functioning public

institutions, a highly developed welfare system and a socially accountable economic sector. A Nordic forum would both contribute to national technology foresight activities and strengthen Nordic influence on ongoing technology foresight activities at European and international level.

Activities of the Nordic Forum may include:

- Regular seminars and meetings on technology foresight.
- Mapping of technology foresight experts and activities. (All Nordic countries and adjacent countries around the Baltic Sea should be covered and initiatives should be matched with the mapping activities currently undertaken by the ESTO-network.)
- Nordic courses in technology foresight issues and methods (which should also be offered to adjacent countries around the Baltic Sea and others).
- A Nordic anthology on technology foresight in the Nordic countries with contributions from Nordic researchers and practitioners.

It would be important to involve the financing organisations in this activity.

The creation of a common follow-up system for relevant international technology foresight exercises (including monitoring of selected trends and early signals)

The Nordic technology foresight forum could be further developed to ensure that there is systematic follow-up of technology foresight exercises that are carried out elsewhere. Overlapping work with corresponding efforts at national and international levels should, however, be avoided. Instead, the focus should be on reporting and refining information that is of particular interest in the Nordic countries, taking into account what kinds of specific Nordic foresight exercise can be expected to occur in the near future.

Activities of a common follow-up system may include:

- Trend analysis of generic technologies (e.g.biotechnology, nanotechnology, materials and the life sciences) based on international data and foresight results.
- Early warning mapping for science and technology based on bibliometric analysis in order to identify emerging scientific and technology fields.
- International benchmarking of Nordic science, technology and innovation indicators.

Although a common follow-up system would be useful, cumbersome structures and procedures should be avoided.

The realisation of concrete technology foresight exercises

Two types of Nordic technology foresight exercises could be launched:

1. *Technology foresight exercises focusing on specific technologies or problem areas* in which Nordic countries have a good prospect of cooperation and also have the need to build a critical mass. The importance of suitable timing for a common Nordic technology foresight has been highlighted, so it would be beneficial if the first joint-efforts could build on the current interests in developing the activities in the field. On the basis of the viewpoints presented by the experts consulted, the following areas seem most promising at the moment:

- Sustainable energy systems and other 'green technologies'.
- Ageing society and the challenges of healthcare and welfare services (focusing on the potential contribution of new technologies).
- Pervasive information and communication technologies.
- Service innovation, knowledge intensive business services etc.
- Technologies for small, isolated societies.

2. *Technology foresight exercises in selected cross-border regions* where Nordic players work to overcome the dividing and diluting effects of national and institutional boundaries. This may include cooperation in the remote Northern districts, as well as cooperation between some Nordic and adjacent countries (for instance Estonia and other Baltic nations). It is important, though, that regional players express an interest in conducting such a foresight exercise, and thus an initial survey among cross-border cooperation regions and players should be conducted. This activity might also match and contribute to ongoing regional foresight activities at European level (FOREN, 2001).

Key players should, however, express an interest and commitment in participating in the technology foresight processes and in using the results. If they do, it will be possible to learn important lessons from joint efforts by all Nordic countries as well as cross-border exercises where selected counties/regions are involved.

Well designed, Nordic technology foresight exercises can generate new knowledge that is shared by the key actors in all Nordic countries. This knowledge can be used to develop the Nordic R&D and its infrastructure as well as to help shape international norms and influence the contents of international research programmes. Because of their cultural background, the Nordic countries could thus play a more important role in promoting equality and well-being in an increasingly technocratic world.

Interesting and fruitful Nordic cooperation in the field of technology foresight will depend, however, on the willingness of the key actors to promote this type of work. Individual companies can benefit from TF processes, but they are often not interested in being the primary engines in pushing forward this type of activity. As technology foresight exercises typically serve a wide constituency with a variety of actors, their natural initiators might be institutions and national-level organisations that are responsible for the coordination and prioritization of research and development. In addition to relevant ministries, organisations such as Tekes and VINNOVA could be active in this respect, as could industrial and professional federations.

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www.energiframsyn.nu
www.norden.org

Appendix 1: Persons who provided information and viewpoints

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Gisli Benediktsson, Director, New Business Venture Fund

Thorvald Finbjörnsson, Head of Section, the Icelandic Research Council

Hallgrimur Jonasson, General Director, IceTec

David Ludviksson, Director, Federation of Icelandic Industries

Vilhjalmur Ludviksson, Director, the Icelandic Research Council

Thorsteinn I. Sigfusson, Professor, University of Iceland

Smari S. Sigurdsson, Finance and Quality director, IceTec

Sveinn Thorgrimsson, Head of Department Innovation and Industrial Affairs, Ministry of Industry and Commerce

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Nordic institutions

Reinhold Enquist, Director, Nordic Industrial Fund, Oslo

Stefan Kovacs, Senior Adviser, Nordic Council of Ministers, Copenhagen

Niels Refslund, Senior Staff Adviser, Nordic Council of Ministers, Copenhagen

Riitta Lampola, Nordic Council of Ministers, Copenhagen

Appendix 2: Introduction Letter

Prospects for a Nordic Technology Foresight
September 2001

Nordic Industrial Fund has supported a pilot project on the prospect for a Nordic technology foresight. The project is conducted by VTT Group for Technology Studies in Finland and Risoe National Laboratory in Denmark and will be completed in the first half of 2002.

Technology foresight (TF) is increasingly used by governments, funding agencies, R&D institutions and private companies as a tool for strategy development, prioritisation of R&D funds, and learning. In the Nordic countries attempts are made to embark on technology foresight activities, but without a common knowledge pool nor coordination and hence no Nordic synergies.

This pilot projects seeks to make a state-of-the-art of technology foresight activities in the Nordic countries and thereby investigate the basis for common TF activities as a means to strengthen an integrated Nordic knowledge region. In particular, the pilot projects seeks to identify Nordic partners with interest in TF, to build commitment and to make a concrete Nordic technology foresight project proposal to be submitted to the Nordic Industrial Fund.

In this preparatory phase of the project, we are seeking answers to the following questions:

1. What do you consider to be a reasonable TF in the Nordic countries?
2. What are the strengths and weaknesses of a Nordic TF?
3. How can a Nordic TF contribute to ongoing TF activities in your country (sector, institution etc.)
4. To which institutions should a TF be oriented - R&D institutions, associations of industries, technological service institutes etc.?
5. Which industrial sectors would you suggest to focus on?
6. Which technologies would you suggest to focus on?
7. Can you recommend central persons or institutions to whom we should take contact?

Thanking you in anticipation

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Bibliographic Data Sheet **Risø-R-1362(EN)**

Title and authors

Technology foresight in the Nordic Countries

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ISBN	ISSN
87-550-3109-9 87-550-3110-2 (Internet)	0106-2840

Department or group	Date
Systems Analysis Department	September 2002

Groups own reg. number(s)	Project/contract No(s)
	PSP 1220030 NIF 01026

Sponsorship

Nordic Industrial Fund

Pages	Tables	Illustrations	References
67	8	82	83

Abstract (max. 2000 characters)

Technology foresight (TF) is increasingly used by governments, funding agencies, R&D institutions and private companies as a tool for strategy development, prioritisation of R&D funds, and learning. Although the Nordic Council of Ministers aims at "developing Nordic region in next 10 years as the most attractive region in terms of education, research and industry", there seem to be no effective mechanisms capable of embracing the various activities and initiatives at Nordic level.

The report analyses the potentials of TF in building a Nordic knowledge region. On-going TF activities in the Nordic countries are described as well as the prospects for Nordic TFs. The potentials of a Nordic TF are closely connected with spatial proximity and shared values, as well as with a willingness to exchange experience and to learn from each other. On the other hand, some doubtful concerns stem from the economic and social differences among the Nordic countries. Nordic foresight cooperation may also remain as a distant academic exercise if proper links to political and economic decisions cannot be made and maintained.

A technology foresight exercise might serve different institutions of the innovation system and the society at large at the same time. The report recommends:

4. The establishment of a Nordic forum for technology foresight practitioners and researchers.
5. The creation of a common follow-up system for relevant international technology foresight exercises.
6. The realisation of technology foresight exercises that involve participants from various Nordic countries (e.g. focusing on specific technologies or problem areas or in selected cross-border regions).

Descriptors INIS/EDB

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Risø's research shall **extend the boundaries** for the understanding of nature's processes and interactions right down to the molecular nanoscale.
The results obtained shall **set new trends** for the development of sustainable technologies within the fields of energy, industrial technology and biotechnology.
The efforts made **shall benefit** Danish society and lead to the development of new multi-billion industries.

ISBN 87-550-3109-9
ISBN 87-550-3110- (Internet)
ISSN 0106-2840

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