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Danish Technology Foresight 2015

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Sponsors: The Danish Government

Type: The project has a national scope and involves conducting eight sector-focused foresight studies. Only 4 focus-areas were selected in the first year in order to allow for flexibility in making final choices.

Organizer: The Danish Ministry for Science, Technology and Innovation

Duration: 2001-2005 **Budget:** €3.2M **Time Horizon:** 2015

Purpose

The purpose of this technology foresight exercise is to gain insights into, and prepare for, future technological developments, market and social needs. It seeks to do so by developing well grounded advanced scenarios on future technological and societal developments that would engender a social debate and dialogue around the future and would help policymakers in setting policy priorities.

PART I: Context and Methods

Context of the Exercise

The exercise is meant to assist government ministries and agencies formulate and develop a framework for new research programmes. It was intended to align the Danish national innovation system with important future technology and competencies needs, and in particular with those of the business sector.

Specific Objectives

- To develop insight into and prepare the system for technological and social requirements of the next 10 years.
- To create future-oriented scenarios as a basis for priority-making in research, product and process development & market development.
- To assist in public priority-setting in the area of research, technology and competence development.
- To develop and consider methods and concepts for conducting technology foresight which could be later used by private and public sector organisations in any future oriented strategy activity.
- To create networks and stimulate dialogue on future challenges and opportunities between industry, innovation system organisations, and interest groups.
- To support broad societal debate on possible, desirable technological developments.

Methods

A Secretariat for the project was set up composed of a mixture of technologists, administrative personnel, and process execution experts.

The Ministry then, after consulting various stakeholders, formed a Scientific Advisory Group - the FFF or Forsknings Faglig Følgegruppe. The FFF initially consisted of three persons but more people were added as time went on to contribute ideas, to advise to the project and to follow and monitor ongoing activities. They provided an overview of

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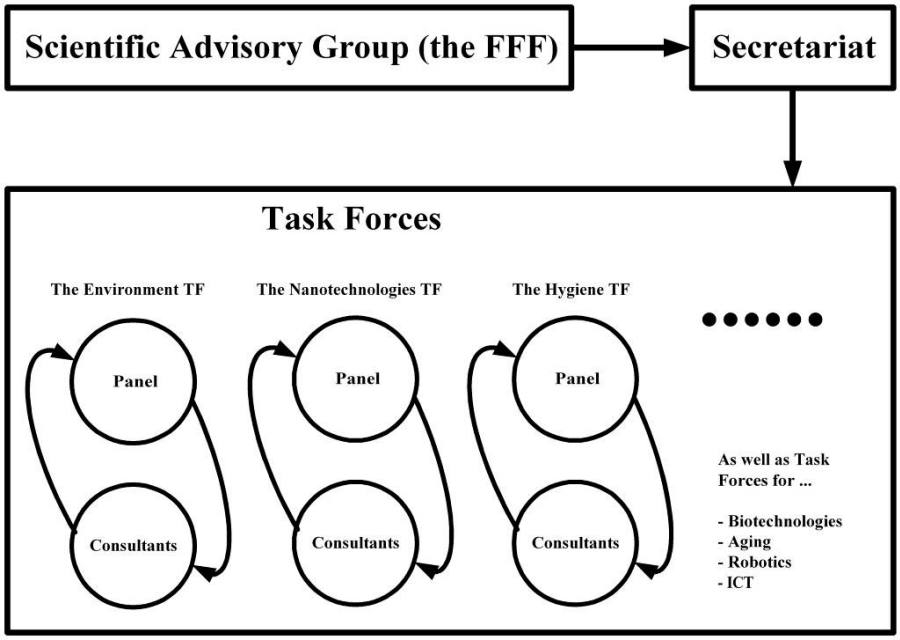
issues, analyzed results and highlighted their relevance to the overall objectives of the exercise.

Steering groups or panels were formed for each focus area that balanced technology expertise with economic and society insight. The members of the panel included directors of businesses, leaders of research institutes, representatives of sectoral associations and interest groups. They were selected on the basis of consultation between the FFF and the Ministry. Their role was to interact with outside consultants who provide more detailed analysis and support to the panel members. They panels are required to analyze and develop visions in the form of scenarios and suggest initiatives for the future.

The exhibit below provides a graphic illustration of the organization of the ongoing Danish Foresight initiative.



Part II: Content & Findings

The foresight project focused on seven themes, the Environment, Biological and Health Sciences, ICT, Hygiene, Nanotechnologies, Aging and Robotics. Work on the last two themes is still in progress. Under each of these themes, areas of application for Denmark and the technologies needed were identified.

Many inter-dependencies exist between themes. For example themes such as ICT have links to Health as well as to Agriculture and Nanotechnologies. Health is also linked to hygiene and the environment. This merely reflects the nature of the problems and challenges that Society faces and the contribution that different disciplines make in providing solutions that address real-world challenges. This also means that the same problems and solutions can appear under different themes and that the different task-forces do not always report results in a similar format.

What follows is an attempt to outline the basic content and the key findings of the work done by the different panels to date:

The Environment Panel

This panel identified the following critical areas for the future:

- Biological resources – water,
- Biological resources – spatial planning,
- Consumption of mineral resources,
- Consumption and spreading of chemicals.

It concludes that the following technologies are required to address these critical issues:

- **Flexible energy systems using wind power**: Flexible systems for electricity and heat product ion are the core in increasing the usage of wind energy, and Denmark is working on a broad front in developing hardware and software.
- **Systematic optimization of energy consumption in buildings:** Denmark has major potential for achieving energy savings by further developing integrated systems and concepts, especially with opportunities existing in new and smart buildings. Denmark has a competitive advantage in energy savings buildings, new materials, building components, insulation, etc.
- **More environmentally-friendly agricultural production:** The perspectives of targeting precision

agriculture and organic farming which are knowledge intensive and enable the targeting of high value crops. Precision agriculture combines IT, remote sensor and robot technology together with further development of traditional agricultural machinery. Organic farming is based on the idea that farming should be part of a natural biological cycle with main aims are to avoid pollution, to maintain/ increase fertility of the soil and work on more closed substance cycles.

- **Design of green materials and products:** Denmark is at the forefront of the development of green products based on environmentally- friendly materials and processes – i.e. green design.

The Bio & Health Panel

This panel identified the following critical areas:

- Health problems related to aging, nutrition, and life style
- Health care structure, including shortage of health workers, costs, & management
- Patient relations, focusing on better quality, treatment of inter-related illnesses, personalized care, and more responsibility to the patient
- Ethical issues arising from new technologies and new procedures

To address these issues the following technologies will play a key role in the future:

- Human genomics and proteomics (including products such Personal Genetic ID Cards, prenatal analysis, gene therapy, etc.): In the field of human genomes and proteomes, the mapping of the human DNA has paved the way a paradigm shift towards individualized and preventive forms of care based on genetic disposition, targeted screening, diagnostics and innovative medical treatments. These include: screening for genetically determined characteristics, more individualized and targeted treatment of diseases and improved prevention of human pathogens (viruses and bacteria transmitted by humans).
- **Stem Cells (for the treatment of neurodegenerative illnesses, traumatic brain and spinal cord injury, etc.):** The research in stem cells from early-stage human embryos, as well as from various types of tissue from adults, aims at engendering many exciting perspectives for developing new forms of treatment in which stem cells are used to replace malfunctioning cells or tissue (stem cell-based cell therapy).
- **Bio-electronics (such nano-robots, biological computing, biosensors, biochips, electronic implants, etc):** Bioelectronics presents many interesting opportunities for fields such as medical equipment technology (including the development of electronic implants for rehabilitation, etc.) and biosensors for monitoring purposes. Recent research in cell properties, and the way they interact with their surroundings, has paved the way for new forms of integration and interaction between biological material and electronic systems, and nanotechnology has permitted the examination and understanding of systems right down to the atomic level.
- **Pervasive Healthcare (such as automatic and mobile monitoring, virtual hospitals, etc):** Pervasive healthcare could be used to give patients, relatives and staff better access to information as and when they need it. There are also many possibilities for home care – healthcare and treatment in the home. Pervasive healthcare can be seen as a way of improving care, communication and the use of resources, and thus has the capacity to optimize the health sector in many areas.

The ICT Panel

Areas identified as being critical for the future include:

- Pervasive computing - computers will play a bigger role in our daily life and surroundings. By 2012 many of the largest Danish companies will have positioned themselves as technology-developers because of their ability and determination to use and integrate pervasive computing into existing services and products.
- Health services - this is seen as a sector where Denmark could start from in its application and development of pervasive computing.
- Facility management, especially of large building, constructing projects, etc.
- Security (digital ID etc)
- Food, this is an area where Danish companies are internationally competitive.
- Entertainment, this is a fast growing area in Denmark especially games and film production

Key technologies for the future include:

- Communication networks and infrastructure,
- Energy saving ICT technology, such as improved batteries and electrical consumption technology,
- MEMS - Micro-Electronic-Mechanical Systems, silicon technologies, sensors, micro-mechanical components, etc.
- Screen Technologies such as OLED - Organic Light Emitting Diode, LCD and digital paper technologies, etc.
- Software technologies.

The Nanotechnology Panel

As a new emerging field its areas of applications remain not so well defined but they are believed to be pervasive in their impact. Denmark is expected to play a leading role in the future development of this technological field. The following technological areas were identified as being critical for the development of the domain and to have a strong relevance for Danish society and its economy:

- Nano-medicine and drug delivery including the establishment of a nano-technology centre for cancer research,

- Bio-compatible materials,
- Nano-sensors and nano-fluids,
- Plastic-electronics,
- Nano-optics and nano-photonics,
- Nano-catalysts & heat technology
- Nano-materials.

These selected fields are areas on which Denmark can build, benefiting from existing research of national excellence and seizing the opportunity to develop whole new industries of strategic importance for the future.

The Hygiene Panel

Hygiene is seen as being of strategic importance in Denmark for the following reasons:

- Infection related illnesses are responsible for about 25% of disease related death worldwide,
- Infections cost Denmark about €250M each year,
- Increased incidence and risk of global spread of infectious diseases,
- Growing resistance of micro-organisms to antibiotics,
- An aging population with reduced immunity,
- Increased mobility between world parts and regions.

The following areas of study have been identified as being critical for the future:

- Bacteria transfer from food to people, between people, and resistant (of anti-biotic) viruses (including cold & flu) and bacteria,
- Food poisoning and intestinal diseases,
- Relationship between antibiotics and resistance,
- Alternatives for existing hygiene practices.

Addressing these issues will require advances in the following technologies for the future:

- Technologies for hygiene in hospitals and other intensive care environments,
- Technologies for hygiene in public and community institutions such as kindergartens, schools, prisons, etc
- Technologies for hygiene in the workplace ,
- Technologies for hygiene in food products,
- Technical Hygiene (technologies for water distribution and sewage handling etc).

Part III: Conclusion & Policy

The various Danish Task Force panels have taken existing national strengths as their starting point. The general message that has come out from the completed exercises is that Denmark will need to focus on sectors and areas in which it has a comparative advantage and where it can make a difference. Denmark has particular strengths in the:

- Environmental and Energy Markets
- Agriculture, Food and Nutrition
- Health, Public Services and Infrastructure.

Accordingly panelists emphasized the importance of interdisciplinary research as a tool that would help make new and emerging technologies more relevant to Danish needs. The real challenge for the future will be the ability to fuse different bodies of knowledge together and work across multidisciplinary teams. The latter will have to be consolidated in the form of institutions. Thus, new multidisciplinary institutions will have to be built to reflect the future. The proposal for a nanotechnology centre for cancer research is a case in point.

The main recommendations made to the policymakers in academia, government and in industry focused on the following:

- Integrating technologies, products and services by cooperating across various fields of applications,
- Interdisciplinary training and education at schools and universities,
- Multidisciplinary research teams and institutes.

Sources and References

At the time of writing this Foresight exercise is yet quite complete. The brief is based on information available at www.teknologiskfremsyn.dk.