

Global trends as drivers

In assessing the future needs for knowledge and competence, the starting points are, on the one hand, global development and economic trends, and, on the other, the way they are reflected in the development of the Finnish society, economy and life of citizens.

DRIVING TECHNOLOGIES

Information and communications technology, biotechnology and material technology are among the global technologies that promote change. Finland has a good competitive edge in many sub-sectors of these fields. This provides a good opportunity for staying at the cutting edge of development, but also calls for a fast commercialisation and the continuous renewal of technological development and thus also business renewal.

Information and communications technology creates new product, production and service opportunities. However, the communication and networking enabled by digital technology significantly change the business environment and practices of businesses, various services and individuals. There is still a long way to go before we can fully utilise information and communications technologies for the benefit of individuals, the industry and society. The main problem in the development of the sector is how to identify and prepare for the real future needs of the users. The contents and services that people are willing to pay for will determine the degree of success in the future.

Biotechnology opportunities reach even further. Increased understanding of living organisms has paved the way especially for the development of new pharmaceuticals and diagnostic methods, vaccines and foods. Moreover, biotechnology can help to improve the quality and efficiency of various materials and production processes in accordance with the principles of sustainable development. The opening up of biotechnological potential has raised many difficult questions with regard to ethics and values. The utilisation of technological applications depends on how well we manage to create jointly accepted principles on the use of such technologies.

The development of **material technology** continues, changing essentially the functionality and intelligence of products, processes and systems. The effects reach the information and communications sector and the energy, environmental, welfare and transportation clusters. Sustainable development sets new requirements for the functionality and intelligence of materials as well as for the consideration of environmental issues and risks. Nanotechnology improves cross-technological cooperation by utilising the opportunities of material technology in efficient small-scale applications.

FINLAND WELL SUPPLIED

International competition and global business environments reach everywhere. In addition to the industry, this affects all social functions and the everyday lives of all individuals. Business operations and capital markets are dynamic; they seek environments that offer the best opportunities for success in open competition. In addition to business and production, also R&D seek the best possible operational environments. This is an important challenge for Finland – how to attract and main-

tain, qualitatively and quantitatively, an adequate share of global investments.

The knowledge-intensive parts of companies' investments in research and development are very important. They strengthen the innovative environment and the structure of the industry. Finland has a good starting point, but it faces the risk of losing the leading position. A small country needs to network and be able to provide strategic benefits related to knowledge and competence and operational environments, such as the quality of life created by means of reasonable taxation, educational opportunities and challenging jobs, in order to compensate for the lack of the economies of scale. Understanding, respecting and experiencing multiculturalism and cultural diversity play a major role.

The importance of locality is important, especially in the development of well functioning domestic markets and intensification of cooperation between the industrial clusters, while the aim is to create a good competitive edge by utilising the opportunities of cross-technological cooperation.

KNOWLEDGE, COMPETENCE AND TECHNOLOGIES CREATE A SOUND BASE FOR SUCCESS

Finland's competitiveness is based on knowledge, competence and technological development as well as on how well these can be utilised. The most important methods of improving knowledge include the strategies and management of knowledge. Time is a crucial competitive factor in the development of new technologies. It is necessary to develop and utilise technological changes quickly enough, yet at the same time to invest in the long-term building up of knowledge and competence. The creation of successful solutions calls for identification and anticipation of the real needs of the end-users. Many services and handicrafts combined with technical know-how will also provide new business opportunities. The development of knowledge requires the right strategic choices both from the public sector and the industry as well as individual businesses. The meaning of the job content, working environment and workplace community is highlighted.

Finland has benefited from smooth interaction and mutual understanding between the public and private sectors as regards the necessary investments. As the industry has rapidly moved toward a technology-intensive direction, the public educational and research investments must follow the requirements. The fact that the public research and development investments have been lagging behind the objectives set by the Council of Science and Technologies in the past few years has aroused concern. This may weaken especially the development of the strategic knowledge and competence base.

The competence of each citizen becomes important. Concern about competent experts in the future requires the development of the educational system in line with social change and the principle of lifelong learning. Finland will need top specialists in various fields in the future, and also the creative people who can combine the various fields. Challenges become more and more cross-technological, which gives a key role to cooperational skills in the society of the future. Finland will also need

to utilise the different resources and approaches of women and men better than before. Individual responsibility for continuous development will be further emphasised.

To maintain well-being and enthusiasm for work, it is essential to pay attention to the reconciliation of work and leisure time and work and family life as well as to benefit from flexibility.

THE DIGITAL ECONOMY AND NETWORKED PRACTICES AS KEYS TO CHANGE

Business operations benefit the networks in an innovative way. Value networks enable and necessitate the renewal of business models and earning logics. The integration of services into the business entity often creates important new opportunities. Everybody does not have to know everything in a networked operational culture.

The development enabled by digital solutions and the Internet have a crucial impact on the development of all industries and social sectors as well as on the lives and practices of individuals. Applications help to improve productivity in the traditional sectors of industry. Information and communication technologies bring about independence of time and space, which improves the preconditions for versatile regional development.

Internationalisation has reached the traditional sectors of the domestic market and issued challenges that are yet unanswered. The Finnish industry and society must improve productivity also in the Finnish market – globally operating businesses are successful in productivity improvement. The challenge is to develop technologies that serve people so that the groups that adapt more slowly to technological changes are not alienated from social development.

SUSTAINABLE DEVELOPMENT CHALLENGES TECHNOLOGY

The environment, health and safety are regarded as the values that people are interested in taking care of and that they are willing to pay for. The values are visible in investment patterns, consumer behaviour and legislative changes. If environmental requirements are taken into account too slowly, it can have adverse results in critical consumer markets. Finnish companies have gained practical experience in this, too.

Environmental requirements are highlighted. The principles of sustainable development are essentially included in competitive business operations. Environmental considerations cause significant changes in products, services, production processes and practices. The changes often call for new technological choices as well. However, the objectives related to the environment also create new business opportunities, which can be advantageous for the developers of new products and services.

The prevention of climatic change is becoming more and more important as a steering factor and boundary condition. Climatic issues are especially linked with energy production, energy conservation and energy policy in general. Finland has been and continues to be able to affect this by the structural change of industry, while moving toward an economy that is technology-intensive, yet relatively less energy-consuming.

SOCIAL DEVELOPMENT INCREASINGLY IMPORTANT

The development of technologies and the industry is based on the plentiful supply of social capital in Finland. A high level of knowledge and competence, citizens' strong support to the maintenance of welfare, trust in the equal and balanced operation of society and uncorrupted government create the basis for national and international competitiveness.

The ageing of the population issues a number of social, educational and economic challenges, while the growing number of senior citizens with more spending power also creates significant business opportunities. It is important to be able to provide developing living and housing environments, pharmaceuticals, equipment and services to enable better living conditions. The independent life-management of people and the efficiency of services must also be promoted.

Technological development may bring along social inequality, which must be taken into consideration in the development of educational and social services. Regional differences are also likely to be highlighted. Products and services that are successful in global markets require an interactive infrastructure around them, which inevitably means certain concentration. Such development must be improved and its adverse effects minimised.

International cooperation is necessary in environmental and safety issues, the steering of the market economy as well as in the improvement in the conditions of slowly developing countries.

Globalisation brings along social challenges and problems in interaction between various population groups and cultures. Multiculturalism issues challenges and creates educational and employment opportunities. It must be ensured that the development of technology is planned and controlled to promote welfare. Tensions between the approaches of different cultures, population groups and political attitudes must also be prevented from creating social and security problems.

Key areas of *technology strategy*

The starting point of technology strategy is the current competitiveness and structure of the Finnish industry and businesses. The general driving forces together with technological development and evaluation provide businesses with opportunities. To benefit from such opportunities, industry and research institutes must possess suitable competence. The objectives must be linked with social needs in the long run, and they must also interact with the strategic choices made by companies.

THE KEY AREAS OF THE TECHNOLOGY STRATEGY ARE

Basic technological competence:

- information and communications technology
- biotechnology
- material technology

The applications of basic technologies:

- intelligent products, processes and systems
- welfare applications
- sustainable development applications
- knowledge-intensive service business
- the business competence in the networked economy is linked with all sectors

These themes are linked to each other – it is a kind of 8D-approach which calls for cross-technological networking.

INFORMATION AND COMMUNICATIONS TECHNOLOGY

Information and communications technology is in a phase of rapid change, and it has an important effect on business. Information and communications technologies are embedded in almost all devices that function seamlessly together and are easy to use. Information networks, computers, software and sensors improve the functionality and user-friendliness of products as well as the flexibility of production, thus improving also productivity. Information and communications technologies support the activity of individuals and organisations in the digital network economy and information society. The utilisation of the technologies linked with broadband, Internet-based and wireless data transfer, software and electronic business is still in the initial stage of growth.

Information and communications technologies are applied to almost all sectors through intelligent products, measuring and automation systems and electronic business systems. The challenge is to widen the business operations related to information and communications technologies and to increase the applications of the technologies in the traditional sectors to improve productivity.

The central information and communications technologies include wireless data transfer, broadband networks, micro systems, natural interfaces, software technologies as well as the management of knowledge and content. The long-term research subjects include the wireless and optical technologies of the next

generation networks, nanotechnology, active environments and self-learning programs. Space applications, which are closely connected to information and communications technologies, combine several technologies, becoming more and more essential in data gathering and operational management systems.

BIOTECHNOLOGY

The availability of genome-level information with the possibility to modify the genotype of living organisms provides a basis for many applications of modern biotechnology. The development of biotechnology has increased understanding of the structure and functions of various living organisms, which offers new opportunities to utilise such information and to modify the features of organisms in the desired way.

Issues related to the ethics of medicine and the safety of food and the environment have become topical in discussions concerning some biotechnological applications. The attitudes of consumers will have an impact on the degree to which gene technologies will be utilised in food production. In society, this calls for jointly approved principles that can be created by maintaining a lively social debate.

Biotargeted pharmaceuticals and drugs enable, among others, the development of new medical applications such as vaccines and diagnostic tests, the targeted breeding of food stuffs, economic plants, microbes and animals, as well as the development of new environmentally-friendly materials and processes. Biotechnological applications can also be used in various traditional sectors, such as forestry, food production and chemistry, as well as new knowledge-intensive sectors. The wide use of biomass may become an important alternative for non-renewable energy sources and raw materials.

Finland is the leading country in many fields of biotechnology. Owing to long-term public investments, Finland now has several bio-centres that provide innovative research environments. A big challenge is to utilise the results of the development work, both by setting up new SMEs and by boosting their growth, as well as by renewing old businesses in many industrial clusters.

The core technologies include genetic engineering, proteomics, bioinformatics, bioprocess technology, cell and tissue culture techniques, stem cell techniques and gene transfer techniques. Gene therapy and bioelectronics will be added to these in the long run.

MATERIAL TECHNOLOGY

The functionality and intelligence of materials generate significant value added in various industries. The development of materials is moving toward functional and intelligent solutions, which issue challenges to process development. Increasing the output/price ratio increases the need to cooperate closely with the end-users of materials. However, sustainable development sets certain requirements for materials, such as added sustainability and recyclability, and increased use of renewable raw materials.

Nanotechnology will have a significant effect on the development of material technology in the long run. Nanotechnology is a

cross-technological research topic and provides an opportunity to combine the characteristics of chemistry, the law of physics and the principles of biotechnology, all on a nanometric scale.

Material technologies are generic. Finnish material development aims at supporting the needs and growing markets of strong industrial clusters. It also strengthens the renewal of the polymer, elastomer, composite and metal refining industry and aims at the foundation and growth of SMEs.

The renewal of the materials business requires strong basic competence and its application. Important fields of competence are surface management, synthesis technology, catalysis technology, composite technology, packaging technology, metallurgy and fibre technology. Long-term research topics include nanotechnology, photonics and cell culture and tissue technology.

BUSINESS COMPETENCE IN A NETWORKED ECONOMY

A networked economy enables organisations to benefit from global networks in a new, innovative way that generates significant value added to customers. Added value is generated by

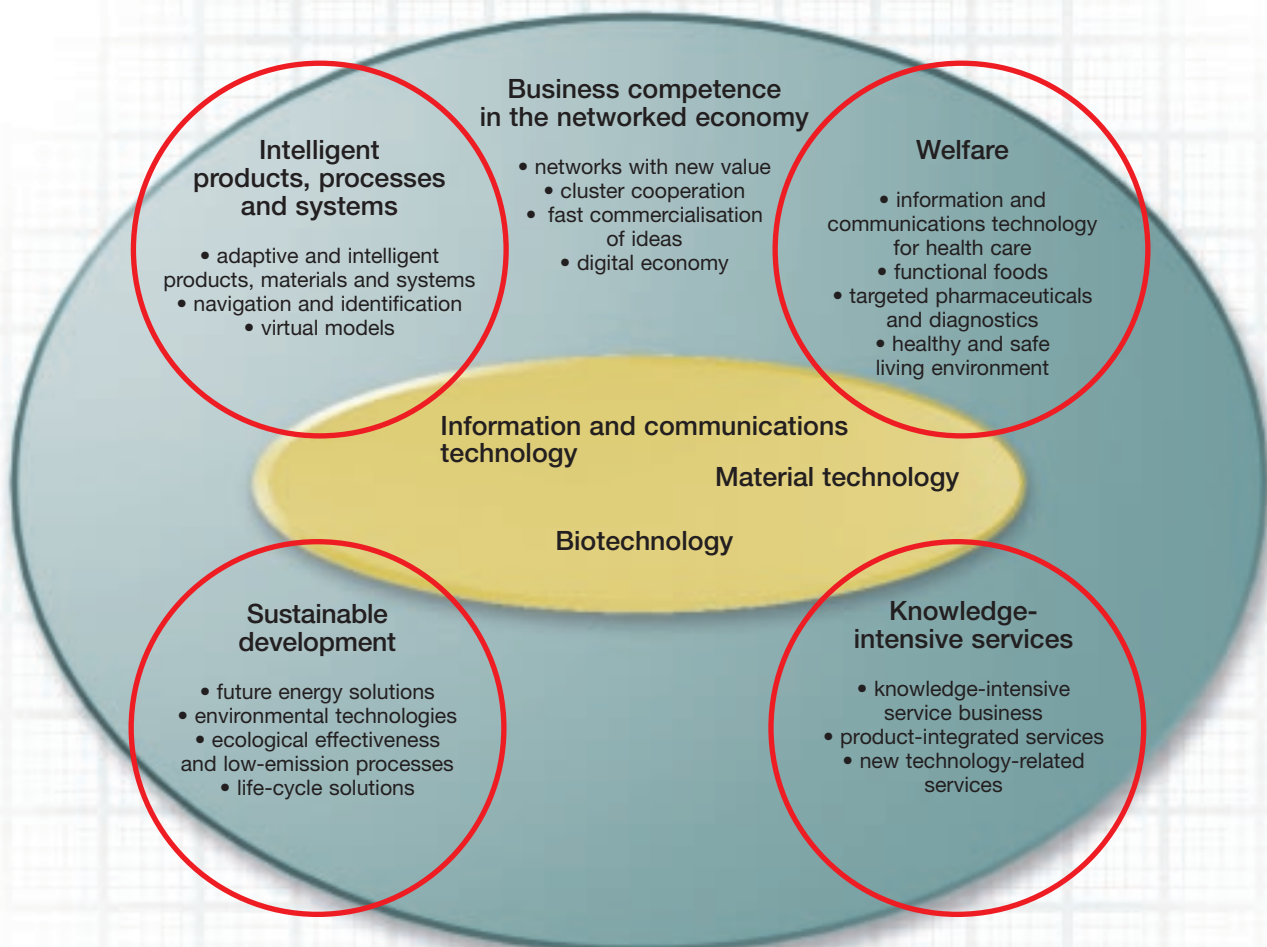
combining the opportunities offered by the new technologies, organisation, management and strategy and intelligent products and services.

The management of networks and the related business competence is necessary for businesses operations both in international and domestic markets. All sectors utilise the business competence of the networked economy. Investments have a comprehensive impact on the competitiveness and productivity of industries and the service sector.

Development work and piloting are often targeted at the new business practices and concepts of the networked economy as well as their applications. Development requires that the research on technologies, commercial science and behavioural sciences be combined. Business competence is often utilised through new information systems.

The applications of the business competence of the networked economy encompass the management of new value networks, the widening of cooperation between industrial clusters and the utilisation of cross-technological cooperation. The targets also encompass the rapid commercialisation of ideas, the

KEY AREAS OF INDUSTRIAL RENEWAL AND WELFARE-PROMOTION



Information and communications technology, material technology and biotechnology are basic technologies, on which applications are based.

management of research and development, life-cycle customer management, internationalisation and global businesses, the management of knowledge and competence, technology entrepreneurship, customer- and end-user-oriented orientation, strategy orientation, long-term orientation and the anticipation and envisioning of needs.

INTELLIGENT PRODUCTS, PROCESSES AND SYSTEMS

Adding intelligence to products, processes, production and systems is based on new solutions developed on the basis of software and hardware technologies, telecommunication systems, miniaturisation, sensors and new materials. Intelligent solutions promote the competitiveness of products through improved functionality and user-friendliness, flexible production and improved productivity.

The development of intelligent products, processes and systems involves the cross-technological application and development of various technologies. The technologies on which intelligence is based are generic, and they can be applied widely. Hence, intelligence is connected to the products, production methods, services and solutions of all clusters.

Important technologies and application targets include learning and anticipating systems, systems that adapt to the operating environment, well functioning and bio-compatible materials, personal and natural interfaces, systems and services based on positioning and identification as well as solutions based on remote diagnostics, remote operations and virtual reality. Other applications of virtual models are management of integrated processes and measuring and automation systems as well as miniaturisation.

Remote and self-treatment, self-diagnosing and error-correcting products, error-correcting biomaterials, holonic production and open mobile communication processes and systems as well as the utilisation of satellite technologies in management and control systems will also be important in the long run.

WELFARE APPLICATIONS

The development of the welfare sector and the growth of markets are based on social choices, changes in lifestyles and population structure as well as on the social development of society. The development of technologies creates better and often more expensive methods of treatment and care also as well as equipment that affects social expenditure.

All sectors of society are involved in the creation of welfare. Social and health care services are responsible for the management of the welfare shortage. The sector is challenged by a scattered service system and the development needs of the services as well as the improvement of efficiency in the public and private sector. The development work mainly utilises basic technologies, such as information and communications technologies and biotechnology. It also combines the needs of businesses, research and the public service providers in the welfare and health care sectors.

The important technologies and application targets encompass a clean and safe living environment, healthy housing conditions, a comfortable and productive working environment, solutions that promote physical exercise, the technologies of independent life-management, distance care and rehabilitation, virtual health care services, functional foods and increasingly effective pharmaceuticals, vaccines and diagnostic methods.

In the long term, the important areas will include targeted pharmaceuticals, new therapies, prevention of allergies, remote surgery, bio-implants, an inspirational environment, living environments that promote well-being, as well as prophylactic precision-nutrients for illnesses resulting from people's way of life.

The reconciliation of the welfare and network societies is a challenge that creates potential for new businesses and services. The application of the modern biotechnological methods calls for ethical discussions about a wide range of medical, food-production-related and environmental issues.

SUSTAINABLE DEVELOPMENT APPLICATIONS

Energy production and conservation, as well as environment, health and safety, have become the boundary conditions of business operations and the factors guiding them. Sustainable development may provide businesses with a competitive edge.

In many fields, Finland is a pioneer in giving attention to sustainable development. Examples of this include the environmentally benign and energy-efficient processes and products of the process and energy industries. The basic level of technology is good in many sectors in Finland, but the application of knowledge is partly lacking, and networking and internationalisation are inadequate.

The technologies of sustainable development affect almost all products, productions and operations. The technologies related to the reduction of environmental pollution and energy production and utilisation play a particularly important role. Material technologies are central in the use and recyclability of raw materials, as well as in energy production solutions. The environmental friendliness of processes and the ecological integrity and energy efficiency of operation are common to all sectors.

One of the most significant challenges is the mitigation of climate change. The related contractual or legal solutions change the business environment. At the same time, they offer business opportunities through emissions trading, energy production and structural changes in consumption.

Lifecycle issues, environmental technologies, recycling and utilisation, biodegradability, material- and energy-efficient products and solutions, simple and closed processes and systems, the reduction of greenhouse gases, renewable materials and energy sources, the decentralised energy production systems and safe and environmentally friendly systems and vehicles are important applications.

In the long run, the important applications will include the large-scale utilisation of new energy forms, hydrogen economy, fusion, climate-friendly solutions and adaptation to climate change, solutions supporting biodiversity, solutions linked with healthy and safe living environments, a community based on sustainable development and molecule economy. The use of satellites as a data-gathering method and a management method of sustainable development, and as operation control systems, will increase in importance.

KNOWLEDGE-INTENSIVE SERVICE BUSINESS

The fact that companies focus on their core businesses and differentiate emphasises the importance of services in value networks. Outsourcing both in the public and private sectors increases the quantity and versatility of business services. The service sector already accounts for over 50 percent of the national economy, and services are essentially included in the innovation system. Services in particular have potential for productivity improvement.

Service business competence is essential for the traditional manufacturing industry, the service sector and new businesses. The production processes of the manufacturing industry aim at getting closer to the end-user. The future competitiveness of the industry is decisively based on services integrated into the product or production. Customised product-service packages and new types of solutions will also produce new business concepts in global markets.

Technology and competence – resources of renewal for *industrial clusters*

A cluster is a group of actors – suppliers, producers, customers and competitors, as well as different types of specialists – that promote efficiency, increase differentiation and create competitive edge. The companies and industries of a cluster are linked to each other with strong commodity, knowledge and competence ties. A cluster is also often referred to as a knowledge concentration. It is a network of networks that involves both cooperation and competition. The entities are studied as value networks

The role of the public sector is to support the growth of industrial clusters by promoting the development of infrastructure, education, research and networking. The competitiveness of a cluster is created by broad interaction that promotes efficiency-improvement through the utilisation of synergy benefits. Different parties can focus on their core competencies and benefit from differentiation.

The competitiveness of an industrial cluster can be measured by its international market share and by the growth of productivity and added value. The key industrial clusters are also a major driver for employment. For example, areas of the welfare cluster, such as healthcare costs and services, describe how various elements of the welfare society are valued and how efficiently they are managed.

Industrial sectors are studied by cluster, emphasising cooperation and networking between industry and its different peer groups. The sizes of clusters have been determined on the basis of the gross production and partly the turnover estimates of the different industrial sectors. The figures of the different clusters are largely overlapping and cannot thus be directly summarised.

DYNAMICS OF FINNISH INDUSTRIAL CLUSTERS

