Summary of

RESEARCH ON NO

Strategic Research Horizons

Ministry of Science, Innovation
and Higher Education

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Published by

The Ministry of Science, Innovation and Higher Education
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DK-1216 Copenhagen K

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Tel: +45 43 63 23 00
Email: distribution@rosendahls-schultzgrafisk.dk

The publication can also be downloaded from the website of Danish Agency for Science, Technology and Innovation: en.fi.dk/RESEARCH2020

Layout: EntenEller A/S
Print: Rosendahls – Schultz Grafisk
1st print run: 2,000
Printed: September 2012

ISBN (printed): 978-87-92776-49-5
ISBN (Internet): 978-87-92776-48-8

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FOREWORD

Denmark gives high priority to research and is among the European countries which invest the most in research and innovation. We do this because the investments contribute to value creation in society. Science enhances Denmark's position in global competition, lays the foundation for future welfare, and makes Denmark stronger.

Where and how the research funds are invested is very important for our society. I am therefore pleased that the most important Danish users of research and research-based knowledge and technology have contributed to identifying the areas in which the largest value creation is expected. The result of the very extensive process is summarised in this pamphlet.

Value creation is to be understood in a broader sense, not just from an economic perspective. Research may for example contribute to adapting Denmark to a green economy, to enhancing health and quality of life, to increasing the innovation capacity in society, and to furthering an efficient, competitive, competent and cohesive society. At the same time, it is important to convert research into innovation in business, into new jobs, and into a public sector with a stronger knowledge-base.

We cannot, however, prioritise everything. If Denmark is to stand out, we must focus on primary challenges and on unique Danish potentials which may drive growth, welfare and future employment.

Also within research, Denmark is a small country. But we have a competitive advantage which we must not forget: Our ability to cooperate across organisational and professional boundaries in order to find new solutions. We can achieve much through innovative solutions and creative use of technology in the intersections between professional disciplines, when society's challenges call for cross-disciplinary solutions.

RESEARCH2020 creates a sound basis for the future prioritising of public research investments. The catalogue will now form the basis for decision when the Danish Parliament

decides how to allocate the strategic funding of research. Not by predicting the next research breakthrough or commercial successes, but by giving priority at a general, strategic level and thereby creating the best possible framework for excellent research and consequently the development of new knowledge and insight.

In this regard, I would like to emphasise that RESEARCH2020 is not an expression of the political priorities of the Government or the other political parties behind the project. The catalogue is the result of an extensive mapping and dialogue process.

In addition to forming a basis for the political prioritising of strategic funding of research, I hope that RESEARCH2020 will also be an inspiration in the prioritising of research funds for example within universities, national laboratories, and private foundations. And that RESEARCH2020 may inspire the individual scientists to commit themselves even more to contributing to solving some of today's significant societal challenges.

Thank you to the many people who have been involved in and contributed to the dialogue about the contents of the RESEARCH2020 catalogue.

Morten Østergaard
Minister for Science, Innovation
and Higher Education

INTRODUCTION

This pamphlet is a summary of the publication "RESEARCH2020 – Strategic Research Horizons", which contains five visions with 14 underlying, promising research themes. RESEARCH2020 reflects society's demand for research-based knowledge. Society's most important users of research and research-based knowledge and technology have identified the most promising areas for future public research investments in Denmark. During the RESEARCH2020 process, a wide group of representatives from businesses, the public sector, interest organisations and universities contributed to identifying the visions and needs for research included in this publication.

RESEARCH2020 focuses on the idea that research investments must be investments which will lead to future value creation. The research is to contribute to solving essential societal challenges and is to be a driving force behind growth, employment and welfare in the Danish society.

The funds set aside by the Danish Parliament for strategic prioritised research areas are distributed by the Danish Council for Strategic Research through large, long-term grants of about DKK 20 million on average. The funds are distributed on an arm's length principle in open competition between the applications with the highest level of quality research, relevance and expected effect. Public-private cooperation, user involvement and international research collaboration are also emphasised. The main focus for RESEARCH2020 is such strategic funding of research, but it is also the ambition that RESEARCH2020 should have a wider scope and provide inspiration for the prioritising of research funds in many other contexts.

The background for RESEARCH2020 is a political desire for a sound basis for the prioritising of public research investments to be agreed upon in connection with the budget negotiations. RESEARCH2020 is to be seen in continuation of the prioritising catalogue RESEARCH2015 from 2008.

Additional information about RESEARCH2020 is available on en.fi.dk/RESEARCH2020.

1. Future energy technologies and systems
2. From knowledge about the environment, water and resources to competitive technologies and solutions
3. Climate and climate adaptation for the future
4. Bio-resources, food and other biological products

1

A SOCIETY WITH A GREEN ECONOMY

1*

The vision is that Denmark should be a society with a green economy. A society which avails itself of the great potentials in the green agenda. Technological and knowledge-based answers to global challenges must be used to strengthen Danish growth, welfare and employment, and contribute to protecting our common nature and environment. A research effort is to contribute to utilising the Danish potential in order to develop competitive environment and energy technologies with an ability to meet future environmental requirements and need for energy, raw material and natural resources. At the same time, research must contribute to an efficient, competitive, and sustainable and health promoting production of food and other biological products, prepare us for adjusting to - and counter-acting - climate change and increasing competition for limited global resources.

The global population is expected to reach about 9 billion in 2050, and the material prosperity is also expected to increase. The development creates growing pressure on biological production, climate, environment and natural resources. There is for example increasing pressure on global energy and raw material reserves. The global demand for energy is expected to grow by about 40 per cent and for some raw materials by more than 80 per cent towards 2035. The development leads to challenges for the security of supply for many countries.

New knowledge and new technology are important prerequisites for the ability to solve the global challenges related to a green economy. Green knowledge and technology are also increasingly in demand abroad, and countries like China, the U.S. and South Korea have made massive investments in this area. The increasing demand increases the opportunity for Danish export of green knowledge, technology and products.

Denmark already holds a strong position in a number of areas which are key in order to be able to create a society with a green economy. In a large number of green areas, Danish research is internationally recognised, and Danish businesses are well positioned regarding the development of resource-saving, climate and environmentally friendly technologies, products and healthy quality food and other biological products.

Green start-up businesses have solid growth potential, and in 2012 Denmark topped the Global Cleantech Innovation Index. In 2010, Danish businesses exported energy and environment technology to a value of about DKK 110 billion, whereas food exports amounted to about DKK 100 billion. There are good possibilities of developing the position as a green pioneer, and the great global challenges must be made into a winning case for Danish growth, welfare and employment.

The realisation of the vision *A society with a green economy* is related to research efforts within four research themes which are particularly promising for Denmark, and which are described briefly in the following pages. The themes are related to different, but coherent, dimensions of the total vision of *A society with a green economy*.

1.1 FUTURE ENERGY TECHNOLOGIES AND SYSTEMS

The global challenges in the energy sector during the coming decades will be great, and many countries are facing a major transition to sustainable energy supply. For many years, oil has been a corner stone in the world's energy consumption, but the situation is changing because of limited supply and production of oil, and the expectation of increased prices. In addition, the consumption of oil and other fossil fuels creates considerable pollution, thereby increasing a potential health risk and contributing to climate problems. Therefore, a number of countries, including Denmark, have committed to reducing the emission of greenhouse gasses considerably.

The global demand for energy is expected to increase as a consequence of a growing population and increased prosperity. This puts pressure on scarce global energy resources. Security of supply and efficient and stable energy supply will therefore be essential to most countries with regards to economy and security policies. The challenges create a need to continue the development of existing technologies and systems, and to develop new ones.

The perspectives of a research effort within future energy technologies and systems are both national and global. The main aim of a research investment is to develop solutions which are internationally competitive and which can therefore contribute to solving both Danish and global energy challenges. Thus the effort may contribute to supporting and developing Denmark's competitiveness and business development and thereby growth and employment. The Danish energy sector holds a strong position and the possibilities of further growth on the international market are considerable.

On the basis of the strong Danish research environments in the energy area, strategic funding of research is to contribute to the development and implementation of energy-efficient and intelligent solutions and to taking a wide range of sustainable and environmentally friendly energy technologies into use. One partial aim is to create a safe, environmentally-friendly, sustainable and cost-effective energy supply and energy consumption and to contribute to securing Danish independence of fossil fuels by 2050.

Furthermore, the aim is to be able to reduce the present energy consumption, while also supporting growth by developing existing, and creating new, industrial positions of strength.

1.2 FROM KNOWLEDGE ABOUT THE ENVIRONMENT, WATER AND RESOURCES TO COMPETITIVE TECHNOLOGIES AND SOLUTIONS

The world's population is growing, and densely populated countries such as China, India and Brazil are experiencing growing prosperity. Globally, production and consumption are increasing, and so are the volumes of waste and the demand for raw materials such as fuel, minerals and metals, and the pressure on eco-systems, biodiversity and natural resources such as cultivated land, clean air, biomass and water. There is also increased focus in many parts of the world on the importance of a clean environment for people's health and welfare.

It is a great challenge to ensure a more sustainable use of global resources, including for example delivering sufficient quantities of water of a quality which meets the requirements regarding people's health, and for the production of food and feedstuff. It is also a challenge to reduce the consumption of raw materials and materials as such in processes and products and to increase recoverability.

The global market for environment-technological solutions is expected to grow considerably. This creates unique export opportunities for the elements of Danish business where environment and resource-effective technologies and solutions are essential competition parameters. The research effort is to contribute to converting challenges into new opportunities for Denmark, and the competitiveness of the businesses is to be strengthened through production focusing on environmentally- and resource-efficient technologies and through adding value to their products through safety and health.

Strategic investments in research are to contribute to developing new, globally competitive and resource-efficient environmental technologies which can further sustainability within areas such as transport, energy, food production, day-to-day consumer products, industrial production, agriculture, buildings, water supply, management and recycling of waste and waste water, soil cleaning, etc. Research is to contribute to limiting the global environment load and to a more sustainable use of limited natural resources.

Furthermore, the aim is to reduce damaging effects on people through increased knowledge of environmental factors – such as particles, chemicals and bacteria – and the development of new methods of risk assessment and prioritising of initiatives to improve prevention, behaviour regulation, and replacement of harmful substances.

1.3 CLIMATE AND CLIMATE ADAPTATION FOR THE FUTURE

The climate challenge is a complex global challenge, and many aspects will reach far into the future. They range from scenarios and predictions of climate change on time scales from decades to centuries via assessments of the importance of such changes to climate change adaptation. Several essential challenges for the Danish and global society need to be acted and decided on during the next few years. The creation of a research-based foundation for climate-policy decisions on large societal investments for mitigating and adapting to climate change is a major challenge in relation to regulation and agreements within the climate area nationally, regionally and globally. Much of the uncertainty regarding the need for climate adaptations relates to the question of how, how much and how soon climate change and the effects thereof will affect various areas. It is important for the development of future solutions and decisions regarding the adaptation to and the mitigation of climate change that the uncertainties regarding the changes are reduced.

Climate change affects a large number of physical and biological systems, including coastlines, water and waste water systems, the water balance, energy systems, infrastructure, building, production of food and other biological products, eco-systems and biodiversity, and new plants, animals and diseases. Many climate adaptation efforts are expected to be made on an on-going basis, but the challenge is to secure a sufficient basis for choosing sensible solutions at the right time. Among other things, there is great uncertainty regarding the extent of regional and global effects of the rapid climate change at the poles and particularly in the Arctic regions.

Global warming, melting of the large ice caps, increased water levels and acidification of the oceans are important factors for the global ecology.

Also the changed conditions in Danish waters will have considerable consequences for the likes of marine eco-systems.

A research effort within future climate and climate adaptation is to strengthen the basis for making political decisions in a number of areas in relation to Denmark's adaptation to climate change and mitigation of related negative consequences. Furthermore, the research must contribute to the development of new, efficient technological solutions in a number of the concrete challenges created by climate change, including support for efficient planning, adaptation and innovative societal and commercial solutions within areas such as new crops, water systems, coastal protection, sewerage, etc. Finally, the research must contribute to obtaining effective regulating systems nationally and internationally in order to limit climate change.

1.4 BIO-RESOURCES, FOOD AND OTHER BIOLOGICAL PRODUCTS

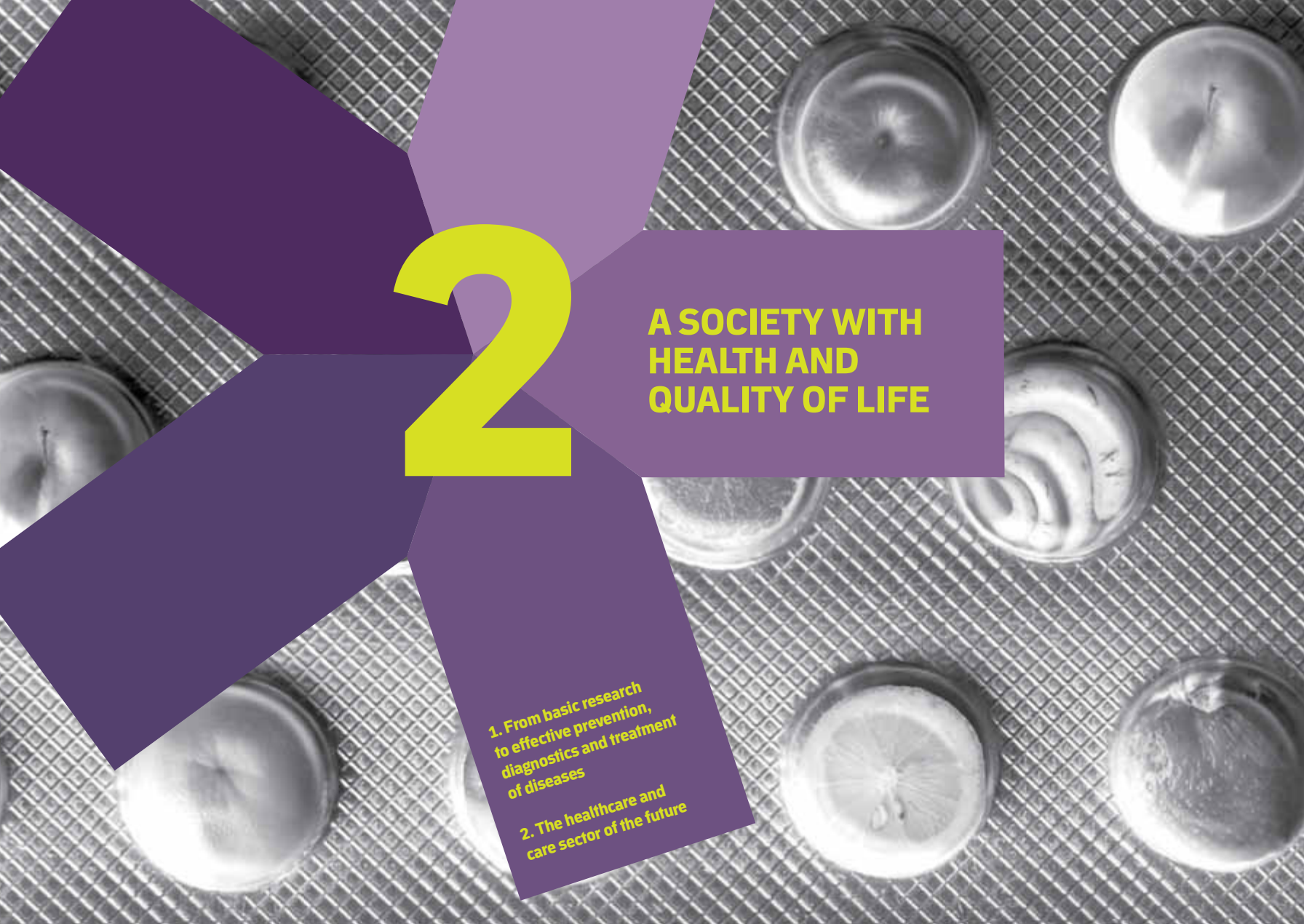
The global demand for food, feedstuffs and bio-energy is expected to grow considerably towards 2050. This can potentially lead to increasing prices and shortage of resources, particularly in the developing countries. This will increase the need for resource-efficiency with a view to the global security of supply. Agriculture, livestock farming, aquaculture and fishery also have a crucial effect on the landscape, water environment, fish stock, climate and biodiversity. In Denmark as well as abroad, consumers make increasing demands on products and production methods. The combination of demand for efficiency, safety, health, quality, environmental considerations, animal welfare and the utilisation of new biological possibilities, means that the biological production is facing a number of environmental, technological, organisational, financial and political challenges and opportunities over the coming decades.

There is a need to combine efficient and competitive biological production and lenient and sustainable use of landscape and the sea,

for example by avoiding waste and increasing the use of waste products. Denmark has made considerable achievements in these areas, but there is still a great potential for development both within efficiency and sustainability, in light of high costs in industry and because of the fact that agriculture and livestock remain an important source of emission of greenhouse gasses and run-off of nutrients into the ground and water environment.

At the same time, food plays a central role for people's health, and there is a need for new knowledge of how consumption, quality and production of food may contribute to solving a number of health challenges. There is also a need for knowledge regarding the development of new non-food products, for example raw materials to replace petrochemical-based materials, new bio-materials from agriculture and forestry, food ingredients and bio-energy. These represent considerable future opportunities of new markets and industrial synergy between food production and for example energy production and the bio-tech area.

Strategic funding of research is to contribute to realising new possibilities within sustainable production, to strengthening business competitiveness and improving the health of the population. The research effort is also to contribute to preventing negative consequences of human activity in relation to the use of resources and the biological diversity. Finally, research is to further food safety and animal health, which are important for maintaining Denmark's strong position on the export markets.



2

A SOCIETY WITH HEALTH AND QUALITY OF LIFE

1. From basic research to effective prevention, diagnostics and treatment of diseases

2. The healthcare and care sector of the future

2*

The vision is that Denmark should be a society with health and quality of life. A society characterised by citizens with high life expectancy, good health, and access to effective treatment for diseases in a cost-effective healthcare and care sector orientated towards the individual citizen. The research must contribute to improved sector organisation, new welfare technological solutions and to empowering and motivating the citizens to care for their own health. Denmark must also utilise the potentials by creating a connection between basic biological research and understanding of diseases and, epidemiology and clinical research in order to develop faster and more precise diagnostics, improved prevention and new, targeted, effective and individualised medicine and treatment.

The demographic development, the relatively low life expectancy in Denmark compared with other OECD countries, new treatment possibilities and increasing patient demands put the Danish healthcare and care system under pressure. The costs of the healthcare sector alone amount to about 8 per cent of GDP. There are also the added costs of for example, elderly care, residential psychiatric facilities, etc. There is thus a great potential in the development of improved prevention and treatment and new organisational, welfare-technological and medical solutions which could optimise the Danish healthcare system and improve individual quality of life. Just like Denmark, most OECD countries are facing great challenges with an ageing population, considerable and increasing healthcare and care costs, a limited economic scope, and in the long-term, a lack of qualified labour. This creates increasing international demand for solutions which may form the basis of a more effective treatment and care and thereby contribute to solving the resource-related challenges.

Denmark holds a strong position, both as a developer and user of new knowledge and technology, and there is a large growth potential with commercial positions of strength within pharmaceuticals, assistive technology and medical-technical equipment. The export of Danish healthcare and welfare technology products accounts for an increasing share of total exports. In 2000, it accounted for about 7 per cent of the total Danish export of goods, and in 2011 it had increased to about 12 per cent. Denmark is able to utilise its unique health registers and the long-standing tradition for effective public-private cooperation on the development and testing of new treatments and welfare technology. The country also has a well-developed public healthcare and care sector with a demand for innovative and effective solutions.

The realisation of the vision aims at a research effort within two research themes which are particularly promising for Denmark. The themes which are described briefly on the following pages relate to different but coherent dimensions of the total vision of *A society with health and quality of life*.

2.1 FROM BASIC RESEARCH TO EFFECTIVE PREVENTION, DIAGNOSTICS AND TREATMENT OF DISEASES

Diseases are a source of lower quality of life for the individual patient and increasing expenses for society. Denmark has a relatively low life expectancy compared with other OECD countries. And the number of people with diseases is expected to increase, due to for example the expected increase in the number of elderly people by about 60 per cent by 2044. Globally, the number of people with diseases is also expected to increase considerably. Both Danish and global challenges create the need for new and more effective prevention and treatment methods, and the development of new medicine.

The majority of the diseases which affect us are due to effects which often occurred many years before the disease was diagnosed. The roots of some diseases lie in the embryonic stage, whereas the development of other diseases depends on various impact later in life. The mapping of the human genome means that it is now possible to study the interaction between genetic heritage and environment. The most recent development within epidemiological research with the use of large cohorts containing data from birth to a later age and advanced statistical technology has produced important knowledge of how societal and biological factors early in life will affect early ageing processes and disease development.

There is great potential in strengthening the connection between the basic biological research on one hand and the epidemiological and clinical research on the other hand. The current treatments in the health sector are not sufficiently based on the fact that each person is unique, in regards to their genes, gender, and lifestyle and living conditions. There is a need for the development of new treatments with specific effect for the individual patient which could replace less effective treatments developed for groups of patients. This approach can be used within most groups of diseases and will enable people to live a healthy life for a longer periode of time and hence postpone the time when the individual changes from being considered healthy and well-functioning to being a patient.

Strategic funding of research is to contribute to improved prevention, diagnostics, treatment and rehabilitation and thereby increased quality of life, longer life expectancy and reduced morbidity. There are great perspectives for industry in utilising a more basic understanding of people's basic biological properties with a view to developing new medicine for prevention and treatment. A research effort must support positions of strength, the need for knowledge and competitiveness in the established industry as well as form the basis for the development of new, knowledge-intensive businesses.

2.2 THE HEALTHCARE AND CARE SECTOR OF THE FUTURE

In Denmark and most of the industrialized world, the healthcare and care sectors are experiencing increased pressure to adapt the current organisation to the demographic and societal development. There is a need for new organisational, financial and technological solutions, and for a sound knowledge base to ensure the use of the most efficient efforts and the best possible utilisation of the resources. The costs of the sector account for a considerable share of public-sector spending in Denmark and many other countries, and expenses are growing faster than the economic growth. Great productivity improvements have already been made in the sector, but it is crucial to continue to ensure good cost control.

The demographic development is leading to more people with a need for treatment or care; for example a strong increase is expected in the number of people with a chronic disease. There are also additional challenges such as cross-sector coordination of services and coherent patient processes and challenges regarding the patients' possibilities of involving themselves in and taking care of their own health. At the same time there will in the long-term be fewer people on the labour market, which will mean additional pressure on public spending.

Strategic funding of research is to contribute to developing new solutions in relation to prevention, treatment and rehabilitation in a cross-sectoral context, including new organisational initiatives, such as optimised and innovative organisation and management or more efficient implementation of evidence-based types of treatment. The effort is to develop improved patient processes, quality and resource utilisation and to remedy shortage of labour in the area. Public-private collaboration will also contribute to creating the basis for better and more innovative and effective solutions, and support new global business opportunities. The export of Danish health and welfare technology solutions accounts for an increasing part of the total Danish exports, and the potential is growing as a consequence of the significant international focus on the area. There are, for example, great potentials in important markets such as Japan, the U.S. and China where there is already great demand because of the demographic development.

3 A HIGH-TECH SOCIETY WITH INNOVATION CAPACITY

1. Digital opportunities and solutions
2. Future production systems and new types of innovation
3. Strategic growth technologies

3*

The vision is that Denmark should be a high-tech society with innovation capacity. A society which develops knowledge, technologies and competences which can secure a strong basis for Danish competitiveness. Research efforts within strategic growth technologies, future production systems and new digital solutions are to strengthen the Danish innovation capacity and productivity development. Research is to further improved societal solutions and export, growth and employment. Innovation, high-tech knowledge and efficient production systems are basic conditions for the ability of businesses to thrive in the global competition. Meanwhile, the solutions to important societal challenges within energy, environment and health depend greatly on progress within strategic growth technologies such as nano- and bio-technology. And the development of the productivity and task performance in the service sector and the public sector is also increasingly dependent on the development and use of new technologies – not least information and communication technology (ICT).

Danish productivity is stagnant, and Denmark's innovation capacity is challenged. There is a dramatic development in the international high technology research and production, and global markets make great demands on the ability to innovate and adapt in relation to products and processes. Within the manufacturing sector alone, 25 per cent of all Danish industrial jobs have been lost during the past 10 years, corresponding to about 110,000 jobs. This tendency risks eroding the Danish innovation capacity. If Denmark is to have a strong position in the global economy in the future, when an increasing number of countries are able to compete on good infrastructure and highly educated – and often cheaper – labour, Danish businesses must choose different competition parameters such as technological spearhead competences, flexibility, cross-disciplinarity, complex production chains, integration of ICT, etc. Knowledge-intensive products, concepts and processes are central to Danish businesses and form an important basis for the Danish competitiveness, jobs, growth and prosperity, and there is great potential for Denmark in this area.

Danish research holds a strong international position within bio-technology and nano-technology, whereas there is a need for a capacity increase for the research within production technology. Denmark is a global leader measured by the use of ICT by the population, businesses and the public sector, but the potentials in the area can be utilised even further. There is also a well-developed network of Advanced Technology Group (GTS) institutes which can accelerate the use of knowledge in small and medium-sized businesses.

The realisation of the vision is related to a research effort within three research themes which are particularly promising for Denmark and which will be described briefly in the following pages. The themes are related to different, but coherent, dimensions of the total vision of *A high-tech society with innovation capacity.*

3.1 DIGITAL OPPORTUNITIES AND SOLUTIONS

During the past 50 years, information and communication technology (ICT) has become increasingly important to society. The development of computers, the Internet, mobile phones, etc. has made ICT an integrated part of all branches of society, and there are great potentials for value creation through the development and integration of solutions based on new ICT in anything from our personal communication through control of the production and administration of businesses to public administration and service production. This applies for example to large welfare areas such as the healthcare and care area. The potential for new and improved ICT-based solutions also aims at a number of societal challenges in relation to sustainability and resource utilisation, for example in connection with intelligent energy supply, education, operation of buildings, logistics and transport systems.

In the private sector, an increasing number of important commercial products, services and core processes are expected to be created through ICT, and for many products and services, ICT elements are crucial for the competitive situation and contribute a large segment of the added-value. Denmark has a considerable industry which depends very much on for example integrated production and control systems, but there is also great potential within the construction and the service sector for the development of new ICT-based technologies and solutions to further productivity growth and competitiveness. Surveys indicate that about one third of the growth in productivity in Denmark can be attributed to ICT, and ICT-based solutions are also expected to play a large role for the future productivity and societal development.

Both the public and private sectors depend on a well-functioning digital infrastructure as a basis for innovation, increased efficiency and value creation. The related challenges include the development of advanced and reliable ICT solutions to control and process the massive data volumes which are collected within the health sector, the monitoring of nature and environment, traffic, financial transactions etc.

A research effort within digital opportunities and solutions is to be a driver of innovation, competitiveness and growth, both in the manufacturing industry and the service sector. In the public sector, new digital solutions are to contribute to a more efficient task performance and higher quality in the welfare services. Consequently, cross-disciplinary, ICT-based solutions are to add benefits to the Danish society within a large number of areas, such as energy supply, health, care, and education.

3.2 FUTURE PRODUCTION SYSTEMS AND NEW TYPES OF INNOVATION

A strong manufacturing sector is very important to the Danish economy and growth potentials. Manufacturing businesses in Denmark are, however, under pressure from a number of factors. These factors include high Danish labour costs and lower production costs abroad. Today, manufacturing businesses have just under 350,000 employees - or 15 per cent of the total Danish labour force. In the course of the past 10 years, 25 per cent of all Danish industrial jobs, or about 110,000 jobs, have disappeared. Many of the jobs have been relocated to Asia or other European countries.

Manufacturing is the basis for a number of research-related and innovative activities and there is a risk that when the production is moved abroad, Danish innovative competences will be eroded even more. If Denmark is to hold a strong position in the future international economy, where still more countries will be able to compete on good infrastructure and well-educated – often cheaper – labour, Danish production must be efficient and innovative and hold a strong position in relation to areas such as flexibility, speed, complexity, product differentiation, intelligent and strategic design, resource-efficiency and user comprehension. Danish businesses must be able to organise and run manufacturing facilities even more efficiently than their international competitors.

Strategic funding of research is to contribute to strengthening Danish competitiveness and prosperity through the development of future production systems and improvement of business innovation capacity. Production systems in this instance mean the entire production facility in which a physical product is made – i.e. systems, equipment and technologies. Production systems also include the organisational and management-related frameworks with immediate relation to the production facility. Production systems will to a large extent control the way in which the different technologies are combined, technically and organisationally, but the development and use of new methods and concepts are also important. Under optimal circumstances, Denmark could become a place for experimenting with

the implementation of new technologies and innovative solutions. Research can influence many sectors – from traditional industries to new production areas – and form the basis for the development of new businesses and jobs. Significant aims are to contribute to maintaining and creating jobs, reducing energy consumption, waste volumes and environmental effect, and to ensure a good working environment.

3.3 STRATEGIC GROWTH TECHNOLOGIES

The increased international competition means that the growth potentials for Danish firms depend on their ability to constantly increase the knowledge content in products, services and processes. Research into strategic growth technologies is of decisive importance to the access of many Danish firms to the latest knowledge and therefore to the competitiveness of the firms and the future prosperity of the country. Strategic growth technologies – such as nanotechnology, biotechnology, materials technology and information and communication technology (ICT) – are technologies which are expected to have a particularly great potential in relation to the development of

innovative products and sustainable solutions, and they are technologies which will often cover several sectors and areas of practice.

Research can bring Danish businesses in the lead in the international race for future green energy and environmental technologies, the development of which is increasingly based on strategic growth technologies. Within the health area, new nano-medicine will, for example, potentially revolutionise the treatment of cancer and a number of other serious diseases to the benefit of both patients and healthcare sector and industry. Research into biotechnology may give us important innovations within the development of treatments against resistant bacteria, the development of individualised medication and health care, and new food technological breakthroughs of importance to nutrition, food safety and food supply. The interdisciplinary research within synthetic biology may potentially deliver solutions which can bring society closer to a bio-based economy by relieving the shortage of food and energy, or contribute to developing production systems which can provide new biological materials and a sustainable replacement to fossil fuels. ICT research has potential to deliver new and improved solutions within a large number of

areas, such as advanced hospital equipment, energy optimisation, improved traffic solutions, prediction of consequences of climate changes, etc. There are numerous examples and possibilities of using tomorrow's growth technologies – especially within the cross-scientific intersection between the different growth technologies, but also in collaboration with the more traditional technologies.

A research effort within strategic growth technologies is to ensure that Danish businesses have the development and innovation level necessary to compete on the expanding global market. In addition, environments are to be created and developed at the universities of a quality which will enable them to play an active international role in the sharing of knowledge and competences - and therefore also will be able to supply highly qualified labour for Danish businesses and the public sector in the future. Furthermore, the research effort is to contribute to creating a basis for improved solutions to a number of societal challenges within for example health, environment and energy.

1. Competitiveness, productivity and growth
2. Effective and innovative welfare and prevention
3. Transport, logistics and living space

4

AN EFFICIENT AND COMPETITIVE SOCIETY

4*

The vision is that Denmark should have an efficient and competitive societal organisation characterised by good resource utilisation, high productivity and strong competitiveness. A research effort is to contribute to improving the basis of Danish decision-makers for strengthening productivity development, competitiveness and growth and to supporting a knowledge-based and innovative public sector which delivers effective preventive efforts and ensures more years with quality of life and a possibility for more people to remain in the workforce. Furthermore, the research must contribute to enabling safe, efficient and sustainable mobility for people and goods and the development of an attractive physical framework in cities and in the country site.

The Danish economy and the welfare society are faced with a number of great challenges. In a few years, Denmark has fallen from third to eighth on the list of the most competitive countries in the world. The Danish productivity development has for a long time been very weak in an international context, and over a number of years, Denmark has lost many Danish jobs. In the public sector, it is a challenge to develop public efforts which will also increase the quality of life for the individual, ensure resource-efficient public-sector task performance and strengthen the competitiveness, employment and growth. Moreover it is a challenge to handle increasing mobility for people and goods efficiently, while also reducing pollution, congestion and transport time. It is an additional challenge to design and create living space which is attractive to citizens and businesses, and which can contribute to creating development and quality of life.

In spite of the challenges, Denmark is a well-functioning society seen in an international perspective. Denmark tops the OECD's "better life index" which includes income as well as welfare in the form of housing, education, health, etc. As the welfare state has an important role in Denmark, there are good conditions for research in the area as well as for converting new knowledge into actual initiatives within prevention and the social area, employment and transport. In a number of societal areas, Denmark has well-developed registers and enormous quantities of data available, which provide unique possibilities for researching and observing long-term effects of public-sector efforts. As far as research is concerned, Denmark also holds a number of positions of strength which can be used in relation to a more efficient and competitive organisation of society.

The realisation of the vision relates to a research effort within three research themes which are particularly promising for Denmark and which will be described briefly in the following pages. The themes are related to different, but coherent, dimensions of the total vision of *An efficient and competitive society.*

4.1 COMPETITIVENESS, PRODUCTIVITY AND GROWTH

It is an essential challenge to develop a society which will further long-term growth in the best possible way. In this connection, the Danish economy depends completely on maintaining a strong productivity development and international competitiveness. Recent years have, however, been characterised by reduced competitiveness and considerable losses of market shares in the export markets, accompanied by the loss of many Danish jobs. Furthermore, the development of Danish productivity has been weak for almost two decades.

The business activities which take place in Denmark and the ability of businesses to compete on the international markets are the result of the interaction among a large number of historical, structural, cultural, political, social, geographical, financial, organisational and legislative factors. Today there is only limited knowledge of the way in which these factors individually – and in collaboration with each other – affect the ability of businesses to compete internationally. Similarly, there is much uncertainty as to the precise factors and mechanisms which create productivity increases.

Strategic funding of research into the conditions and frameworks which are important to productivity development and competitiveness must contribute to utilising knowledge of competitiveness and productivity in society. Thus, the research is to make sure that both at a national, regional and local level, the decision-makers will have a strong basis for the planning of education, research investments, business legislation, financial regulation, employment policy, efforts to promote industry etc., so that economic growth, prosperity and welfare in Denmark can be ensured for the future, while also considering other societal goals.

4.2 EFFECTIVE AND INNOVATIVE WELFARE AND PREVENTION

It is an important challenge to organise the public sector and its efforts so that they will further the quality of life of the individual citizen and strengthen Denmark's economy, of which the public sector accounts for about half. Citizens with good education, employment and a healthy lifestyle are more productive and contribute to the economy with larger annual tax payments and more years in employment than citizens with more difficult conditions in these areas. Meanwhile, insufficient education, unhealthy lifestyle and social problems will often lead to societal costs regarding the health system, transfer payments, social initiatives, police, prison services, etc. Just under 1 million Danes of working age are unemployed today. A little more than half of them are not available for work, and it is a major challenge to mobilise additional people from this group. Together with absence due to illness, this is a large burden on the economy, and it reduces the quality of life for those affected.

Effective prevention has great potentials across many welfare efforts in relation to increasing quality of life, lifetime, the supply of labour and in relation to reducing the need for public-sector services. Therefore, prevention is a beneficial societal investment which will move citizens from the cost side to the income side, and which will also increase people's well-being. In a large number of areas in the public sector from health promoting initiatives to prevention efforts, there is, however, a need for far more and better knowledge as to which efforts are best and most resource-efficient. There is also a need to understand how the efforts work and which efforts are ineffective or even damaging, just as there is a need for the development of brand new, effective measures. Furthermore, there is a need for research-based development of new solutions and models at state, regional and municipal level, including new technological solutions, public-private cooperation, organisation and management models, management roles, incentive structures, levels of freedom, employee and consumer involvement, and a stronger knowledge culture.

Strategic funding of research must contribute to the development of an innovative, efficient and knowledge-based public sector and ensure better prevention, which will give more citizens more positive and healthy years, as many as possible of which are used in employment. The research effort is to contribute to knowledge-basing, developing and future-proofing public initiatives, including renewing the interaction between the institutions, jobs and welfare payments of the welfare society, and preventing social marginalisation and illness, including the development of physical and mental disabilities. The research must also contribute to the development of the labour market and the possibilities of increasing the supply of labour among the older generations and marginalised groups in society.

4.3 TRANSPORT, LOGISTICS AND LIVING SPACE

Transport and logistics are vital connections in today's society, and the mobility of people and goods by land, by sea and by air is increasing and is expected to continue to increase. In light of the growing congestion, transport and logistics systems – both in Denmark and abroad – will be facing a number of challenges in the coming decades. This applies in relation to the environmental effects and integration of transport into town and landscape.

Energy efficiency is an essential challenge to the transport and logistics sector both in Denmark and globally – not least in light of the goal of a transition towards independence. In Denmark, the sector's emission accounted for one fourth of the total emission of greenhouse gasses in 2010. Transport and its infrastructure are also related to an extensive use of acreage, acidification, production of scrap metal, etc. In addition, there are noise problems and particle pollution, which are very important for the health of the individual. In Denmark, essential improvements have been achieved in a number of these areas, and new types of mobility may further reduce the negative effects.

Well-functioning cities are of great importance to today's societies. Today about 50 per cent of the world's populations live in cities, and the figure is expected to increase considerably so that the areas outside cities will be increasingly depopulated. Increased urbanisation puts pressure on the cities to ensure that they will continue to be safe and sustainable, cohesive units without too much congestion, noise and pollution. At the same time it is a challenge for rural areas to create attractive living space where people will want to live and work, or visit as tourists, and where businesses find it attractive to locate activities and investments.

The research effort is to contribute to the development of more efficient and environmentally-friendly transport systems and well-functioning towns which are able to meet the needs of society, citizens and industry and reduce the societal and environmental costs. In addition, research is to contribute to ensuring an improved basis for decision-making regarding long-term investments in the transport sector and create good framework conditions for the production and services of businesses in the public and the private sector. Furthermore, research is a central condition in relation to creating new innovative solutions and additional commercial possibilities, and maintaining positions of strength within for example logistics and maritime transport, and improved traffic safety. Finally, a research effort could contribute to improved planning and organisation of cities, residential areas and landscapes which will improve the opportunities for development and quality of life.

5

A COMPETENT, COHESIVE SOCIETY

1. Education, learning and competence development

2. Cultural understanding and cross-cultural competences

5*

The vision is that Denmark should be a competent, cohesive society. This means a society in which the citizens have a high level of education and competence which will meet the needs of the individual and society, and where knowledge, creativity and cultural understanding will enable citizens, business and the public sector to seize the opportunities created by globalisation. A research effort is to contribute to a well-functioning education system based on good opportunities for everybody to be involved as active citizens in a globalised world and which will ensure good possibilities of acquiring useful qualifications and competences, which are important conditions for a strong competitiveness, a flexible labour market and new growth.

A high level of education will provide the basis for societal development. Denmark is a small, open knowledge economy which depends fully on a well-educated and flexible workforce and a close interaction with the world around us. Openness towards the world around us will strengthen competitiveness, and a strong international connection is very important for prosperity and the opportunities for growth and welfare. There is a need for sound cross-cultural competences in order to find constructive solutions to the challenges which globalisation creates for Denmark, and to seize the opportunities. Globalisation means growing world trade, more cross-border investments and a more mobile workforce. A large part of the Danish population meets, knows and works together with people from many different parts of the world. A well-founded cultural understanding and cross-cultural competences are increasingly important for the Danish society.

Generally, the foundation is solid. Denmark is a competent and cohesive society whose population is able to manage in international contexts, and Danish businesses are globally competitive. But the Danish competitiveness is under pressure, and Denmark has only been about average in recent international comparisons of educational level, although only a few countries invest a larger share of their GDP in education. During recent decades, a number of countries have caught up with the previous Danish edge regarding education and competences.

The realisation of the vision relates to a research effort within two research themes which are particularly promising for Denmark and which will be described briefly in the following pages. The themes are related to different, but coherent, dimensions of the total vision of *A competent, cohesive society.*

5.1 EDUCATION, LEARNING AND COMPETENCE DEVELOPMENT

Education, learning and competence development are crucial for the future development of productivity, growth and employment. At the same time, education is an important basis for good opportunities in life for the individual.

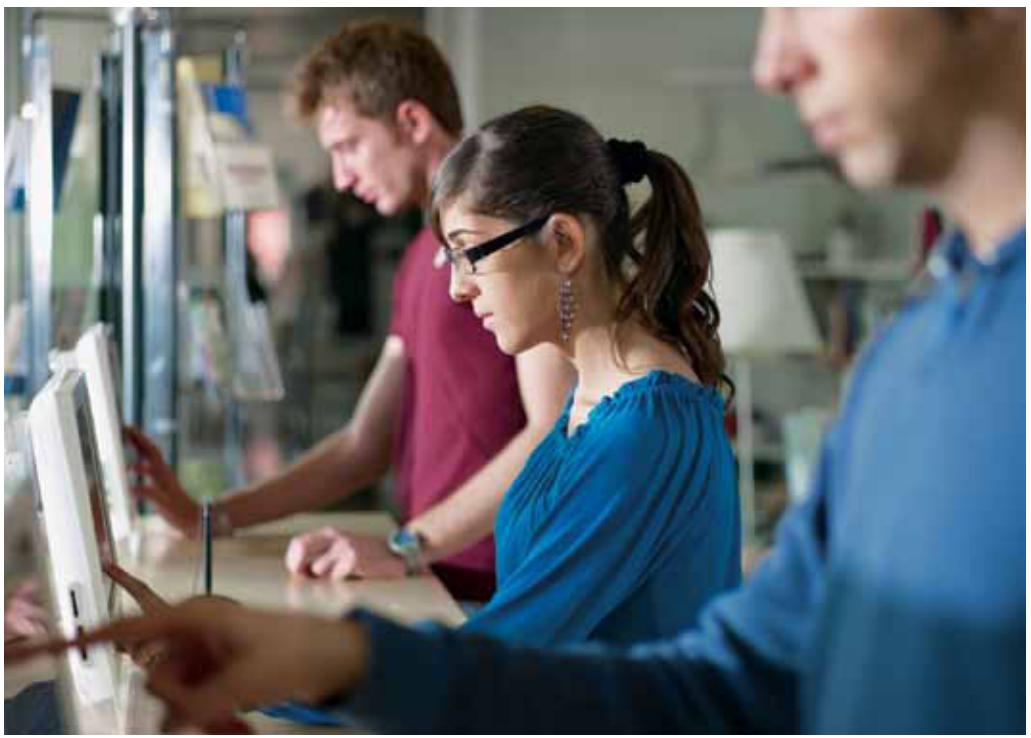
A well-educated and flexible workforce is important for the economy. In addition, a good educational system which ensures that everybody from an early age has good opportunities and is encouraged to acquire useful qualifications and competences will be of great importance to equal opportunities and cohesion in society. It is therefore crucial that all children and young people get an education of a high quality, and that all adults will have good learning opportunities throughout their lives.

Denmark is one of the countries which invest the most in education, but international surveys in recent years show that there are quality issues in parts of the Danish educational system. For example about one in seven students leave school today without sufficient skills in reading and mathematics to be able to complete upper secondary education. Meanwhile, the level of education in many other countries has increased more than that of Denmark in recent years. There is a need to ensure a strong educational system where pupils at all levels will learn more and where they will get good opportunities to improve their qualifications. The quality of education must be strengthened at all levels, and teaching is to be based more on knowledge of what will work in the practical teaching context instead of on habit and routine.

Strategic funding of research is to contribute to strengthening the Danish educational system and a high level of education and competence

in the Danish population, and to making sure that as many people as possible will get qualifying education.

Furthermore, the research effort is to contribute to ensuring that everybody from an early age will be encouraged to complete an education and to develop a Danish position of strength as an education and knowledge nation. The aim is to increase the cohesion in society and strengthen the basis for future-proofing growth, welfare and employment.



5.2 CULTURAL UNDERSTANDING AND CROSS-CULTURAL COMPETENCES

Globalisation is increasing. A large part of the Danish population meets, knows and works together with people from many different parts of the world. Understanding of and interaction with other cultures are important to prepare Denmark – citizens, businesses and public authorities – to act efficiently in a world where different cultures meet.

In many societal areas a good cultural understanding and strong cross-cultural competences are very important. This means having an insight into your own values, norms and way of life and those of other people, and an ability to communicate with and understand people with a different history and culture.

Globalisation means growing world trade, more cross-border investments and a more mobile workforce. Danish businesses are deeply integrated in the global market, and sound cross-cultural competences are therefore necessary when firms establish themselves on international markets, engage in out-sourcing and enter cross-border value chains. This applies in relation to neighbouring areas such as Germany and Sweden, and also to more remote and new growth markets, such as Brazil, Russia, India, China or Korea. Knowledge and information sharing takes place across time zones, cultures and languages, and globalisation provides access for businesses to new partners throughout the world.

Research-based knowledge within cultural understanding and cross-cultural competences may also contribute to furthering successful integration. Denmark has about 360,000 immigrants and descendants of immigrants with a non-western background. In spite of a considerably increasing employment rate for this group and successful education of especialy girls from ethnic minorities, a little more than 40 per cent of the non-western immigrants and their descendants are still outside the workforce compared with 20 per cent of people with a Danish background. Knowledge of cultural differences and similarities may for example contribute to improved cultural encounters at the workplace, at the citizens' service office, in the classroom, or in the emergency room.

A research effort is to create a basis for utilising the opportunities provided by and to meet the challenges created by globalisation. The efforts are to prepare Danish society with the cross-cultural competences necessary in a globalised world. In this regard, an important aim is to contribute to strengthened competitiveness and cohesion, improved integration efforts, increased supply of labour, and prevention of marginalisation and radicalisation.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THE RESEARCH2020 PROCESS

THE RESEARCH2020 PROCESS INCLUDED THREE PHASES AS ILLUSTRATED IN THE FIGURE TO THE RIGHT AND DESCRIBED IN THE FOLLOWING.

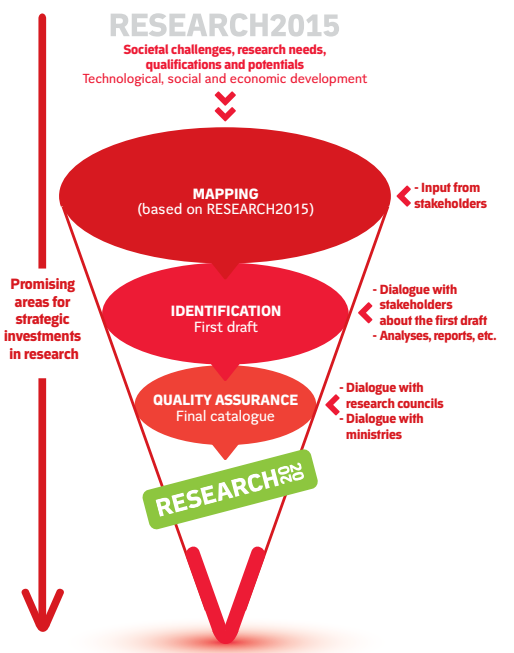
1) Mapping of research needs on the basis of RESEARCH2015: In May 2011, the Danish Agency for Science, Technology and Innovation invited a number of stakeholders (ministries, research councils, universities, industry and interest organisations) to make suggestions for the RESEARCH2020 process on the basis of the previous basis for prioritising, RESEARCH2015.

2) Identification of themes for RESEARCH2020 in dialogue with the stakeholders: In September 2011, the Danish Agency for Science, Technology and Innovation received suggestions from the stakeholders for important research themes. On the basis of the suggestions, the agency prepared a first draft for a RESEARCH2020 catalogue. The suggestions received have formed by far the most important foundation, but a more extensive knowledge of the Danish research landscape within the theme areas in evaluation, research barometers, bibliometrics, statistics, premises analyses, etc. has also been included.

In December 2011, the stakeholders received the first draft for RESEARCH2020, which then formed the basis for an oral as well as written dialogue during the period January - February 2012.

3) Quality assurance and substantiation: During the period March - April 2012, ministries and the Danish Council for Strategic Research and the Danish Council for Independent Research provided assistance in quality assurance and substantiation of the draft RESEARCH2020 catalogue, including a substantiation of the Danish qualifications for being able to accomplish research initiatives within identified themes.

The RESEARCH2020 process



CONTRIBUTORS

Organisations
AC (The Danish Confederation of Professional Associations)
Conference of Rectors for Artistic and Cultural Education
Danish Agriculture & Food Council
Danish Fishermen's Association
Danish Maritime
Danish Medical Association
Danish Patients
Danish Regions
Danish Shipowners' Association
DEA/FUHU
DJOEF
FTF - Confederation of Professionals in Denmark
GTS - Advanced Technology Group
LO, The Danish Confederation of Trade Unions
Local Government Denmark
Organization of Danish Medical Societies
Rectors' Conference of University Colleges Denmark
SEDIRK
The Confederation of Danish Industry
The Danish Academy of Technical Sciences
The Danish Association of Managers and Executives
The Danish Association of Masters and PhDs
The Danish Association of the Pharmaceutical Industry
The Danish Bankers Association
The Danish Chamber of Commerce
The Danish Construction Association
The Danish Consumer Council
The Danish Energy Association
The Danish Forest Association
The Danish Metalworkers' Union
The Danish Society of Engineers
The Danish Wind Industry Association
Women's Council in Denmark

Ministries
The Ministry of Business and Growth
The Ministry of Children and Education
The Ministry of Climate, Energy and Building
The Ministry of Culture
The Ministry of Defence
The Ministry of Economic Affairs and the Interior
The Ministry of Employment
The Ministry of Food, Agriculture and Fisheries
The Ministry of Foreign Affairs
The Ministry of Gender Equality and Ecclesiastical Affairs
The Ministry of Health
The Ministry of Science, Innovation and Higher Education
The Ministry of Social Affairs and Integration
The Ministry of Taxation
The Ministry of the Environment
The Ministry of Transport

Universities
Aalborg University
Aarhus University
Copenhagen Business School
IT University of Copenhagen
Roskilde University
Technical University of Denmark
University of Copenhagen
University of Southern Denmark

Research Councils, etc.
The Committee for Scientific Investigation in Greenland
The Danish Council for Independent Research
The Danish Council for Research Policy
The Danish Council for Strategic Research
The Danish Council for Technology and Innovation
The Danish National Research Foundation
The Danish Space Board

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RESEARCH2020 – Strategic Research Horizons

This pamphlet is a summary of the publication "RESEARCH2020 - Strategic Research Horizons". RESEARCH2020 contains five visions and 14 themes which identify promising strategic research areas for Denmark. Visions and themes aim at areas where Danish research and new knowledge may be the driving force in the development of prosperity or contribute to solving significant societal challenges.

RESEARCH2020 is to be seen as an extension of "RESEARCH2015 – A basis for prioritisation of strategic research". The background for both catalogues is political agreements to improve the basis for political prioritisation of funding for strategic research investments.

The RESEARCH2020 catalogue is the result of an extensive process, through which a wide range of stakeholders from universities, research councils, ministries, industry and interest organisations, etc., have been involved in identifying the essential and most promising research areas for Denmark.

For more information please refer en.fi.dk/RESEARCH2020