

# **Manufacturing 2025**

**Five future scenarios for Danish  
manufacturing companies**



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© Center for Industrial Production and Department of Mechanical and Manufacturing Engineering

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# Preface

How can Danish manufacturing companies sensibly retain their production in Denmark – and what knowledge is required to do so? This question is answered by a number of manufacturing companies, researchers from three Danish universities and two labour market organisations in this publication, based on long-term cooperation within the framework of Manufuture.dk, the Danish platform that forms part of the EU technology platform Manufuture.

This publication is meant to inspire Danish companies in their search for innovative solutions that will contribute to the development of competitive production based in Denmark.

In more concrete terms, the work will be used to influence the research agenda of the EU programme 'Factories of the Future'. Efforts will also be made to establish a number of consortia that will prepare concrete research applications to this and other national and international research and development programmes.

At the same time we hope that this publication will contribute to the debate on the future of Danish manufacturing – and not least to a discussion of political, research and educational measures that should be taken to support Danish manufacturing in 2025.

It is the intention of the platform that this publication should function as a dynamic document that can be continuously updated as it is distributed and discussed in various settings. Manufuture.dk therefore welcomes any views and comments.

Morten Buhl Sørensen, Danfoss  
Chairman, Manufuture.dk





## Summary

This publication examines what manufacturing companies of the future might look like and the knowledge requirements entailed by this. The examination thus provides an outline of what is required for Denmark to maintain a strong and competitive manufacturing sector in 2025. Behind the publication are five Danish manufacturing companies, three universities and the two largest labour market organisations.

The publication shows how manufacturing companies in a Danish context can organise their resources and efforts to obtain an advantage in global competition by exploiting the special competences and business conditions that characterise Danish society.

Compared to many other nations, the Danish economy is open, and the Danish attitude towards global cooperation is very positive. The Danish business culture provides a good breeding ground for efficient organisational forms, characterised by e.g. dialogue and inclusion of employees, just as Danish employees are keen to contribute to finding innovative solutions. At the same time, the Danish business structure presents

some special challenges because it consists primarily of small-sized businesses with limited resources.

On the basis of the Danish advantages and challenges, five future scenarios of profitable and sustainable manufacturing in Denmark in 2025 have been elaborated. A common feature of the five scenarios is that production provides an important framework for product development and innovation. If production disappears, so does a major contributor to our innovation capabilities. The five scenarios are proposals for successfully maintaining knowledge and innovative ability in Denmark.

The future scenarios have been constructed on the basis of Danish conditions, but they cannot be attained without special effort. Knowledge requirements must be met if the scenarios are to be realised. The publication therefore outlines the knowledge requirements connected with each of the scenarios. In this connection, a catalogue of related research topics is elaborated simultaneously with this publication. The catalogue is available at [www.manufuture.dk](http://www.manufuture.dk).

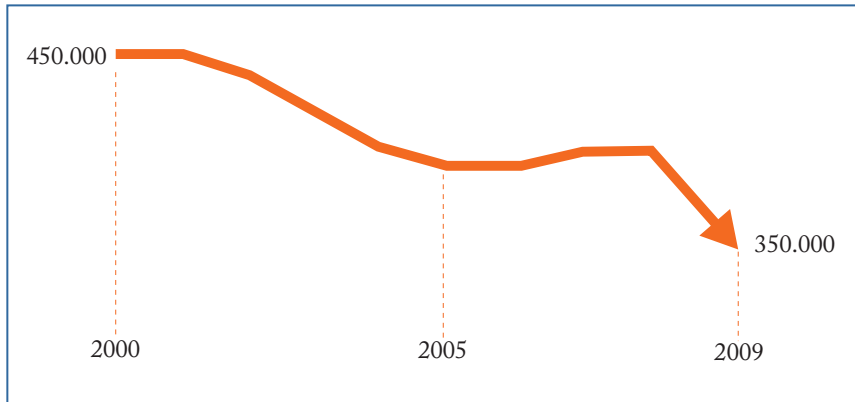


Fig. 1

### Total number of employees (yearly average)

100,000 industrial jobs lost

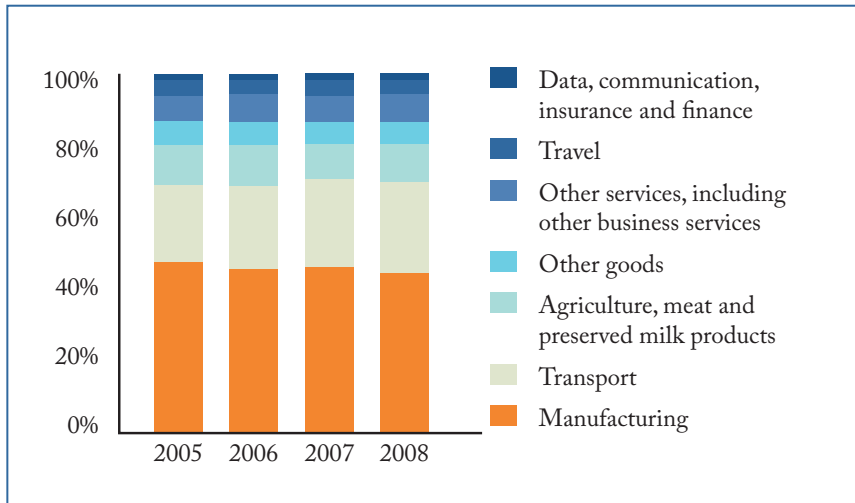


Fig. 2

### Danish exports 2005-2008

Distributed by sector

# Danish manufacturing under increasing pressure - innovation required

The Danish manufacturing sector is responsible for 45 per cent of the Danish exports, employs about 350,000 people and demands services to the value of DKK 150 billion from other sectors. At the same time, the Danish manufacturing sector provides a considerable contribution to privately funded research – DKK 14 billion out of a total of DKK 32 billion.

In other words, companies in the manufacturing sector represent an important part of the basis for the Danish economy and for a large number of companies in other sectors that supply services of various types, e.g. transport, construction, consultancy, technological development, education, etc. The Danish welfare state is highly dependent on an internationally competitive manufacturing industry.

## Increasing pressure

Danish industry is, however, under strong pressure. The Danish cost level increasingly represents a challenge particularly for traditional industry e.g. in comparison to Eastern Europe and China. Therefore, it

is also increasingly challenging for Danish manufacturing companies to maintain their Danish manufacturing base. Also, Denmark traditionally imposes stricter requirements on manufacturing companies in terms of environmental consciousness, working conditions, etc.

In its analysis of manufacturing exports in comparison to wage competitiveness, Denmark's Nationalbank points out that increased globalisation exposes export-oriented businesses to increased competition from low-income countries and that this places great demands for innovation, increased productivity and transition readiness in Danish society<sup>1</sup>.

Headlines such as 'Denmark's welfare threatened by manufacturing downturn'<sup>2</sup>, 'What will Denmark live on?'<sup>3</sup> have been common in the newspapers in recent years. The seriousness of the situation is underlined e.g. by employment in the manufacturing sector falling by more than 100,000 jobs over the past ten years.

Despite these problems, there are fortunately also success stories involving manufacturing companies that have succeeded in exploiting the global opportunities to create progress and growth.

## A European problem

Not only Danish manufacturing companies are under pressure – this is a European phenomenon. Manufacture, a European organisation whose objective is to promote transformation of the European manufacturing sector to enable it to handle “high-added-value products, processes and services, secure high-skills employment and win a major share of world manufacturing output in the future knowledge-driven economy”, has been worried by the development for a long time.

The threat comes not only from an increasing share of traditional manufacturing being moved to low-wage areas such as China and India but also from increasing competition within high-tech production. More and more developing or newly developed countries, such as e.g. Korea, are rapidly build-

ing competences within high-tech research, manufacturing automation, innovation, etc. China is also increasingly making its mark within these areas<sup>4</sup>.

As a result of the economic crisis, Europe's position in the world economy is weaker in 2010 than it was in 2008, and Europe is losing ground to the USA and China<sup>5</sup>.

## **Manufacturing, knowledge and innovation**

Manufacturing is not only a matter of physical transformation of materials but must be seen in a broader context in which interaction between product development, production techniques, sales/marketing, customers and suppliers is crucial.

Manufacturing must be perceived in a new manner and as an important framework for product development. Manufacturing must be perceived as a 'knowledge container' that contributes to business creation and innovation rather than evaluated on the basis of costs and productivity only. This broader

view of manufacturing is supported by a report on the future of European manufacturing, which points out, among other things, that 'R&D drives new developments in manufacturing, but more importantly, manufacturing is the contextual river for more R&D<sup>6</sup>'.

This view also implies that companies not only offshore and outsource their manufacturing activities. Knowledge jobs within administration, research and development increasingly follow, which underlines the close connection between physical production and knowledge production.

## **Global value chains**

Today manufacturing takes place in open global value chains. This is true also of Danish manufacturing companies. Especially large companies organise their manufacturing activities in global value chains. This provides companies with optimum access not only to new markets but also to technology, research and highly qualified labour. For example, Danfoss now has larger production facilities in China than in Denmark, and

China is currently the group's third largest market<sup>7</sup>.

The increased geographical distribution of manufacturing activities introduces a number of additional costs because the distance – in terms of geography as well as structure and management – puts pressure on the flexibility and responsiveness of companies and generally demands an active preparedness to coordinate in the form of a higher degree of formalisation and more extensive communication systems.

Even if these challenges are overcome, their existence calls for an ongoing discussion of the structure and centre of the value chain. Competition is global at all levels: Management, research, competences, resources, labour, etc.

## **Innovation required**

As a nation, we must challenge our current perception when production is increasingly organised in global networks. More than ever, our nation needs new models that point towards intelligent, high-tech knowl-

edge-based manufacturing that will serve as a sensible basis for maintaining production and innovation in Denmark.

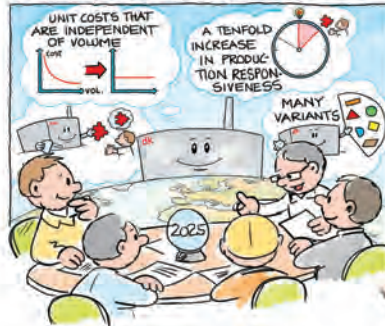
This involves huge challenges for Danish society and Danish manufacturing companies in terms of developing not only new business models but also a basis for knowledge and education capable of supporting the new models and the development required in order for Danish industry to adapt to the new conditions.

There is an indisputable connection between research & development and the possibilities of maintaining jobs in Denmark. A recent survey indicates that on average, companies engaged in research and development activities experience a productivity per employee that is 9 per cent higher compared to innovative companies which are not engaged in research or development. Furthermore, average productivity per employee for innovative companies is 6 per cent higher compared to companies which are not engaged in innovation, research or development.

Within the manufacturing industry, productivity per employee for companies engaged in research and development is 23 per cent higher than for companies which are not engaged in research and development<sup>8</sup>.

The concept of productivity should perhaps rather be perceived as one of efficiency, which measures the total value added to the business.

WS 2. Theme: Diversity vs. costs



WS 1. Theme: Time horizon 2025



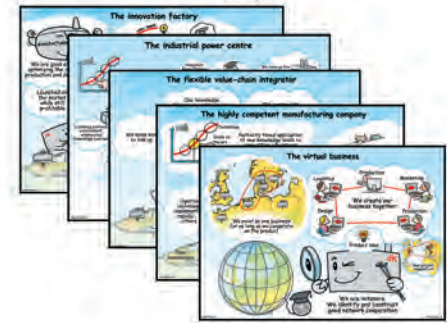
WS 3. Theme: Sustainability



WS 5. Theme: Summarising/general scenarios



WS 4. Theme: Flexible localisation



# 2025 - a project for the future

In cooperation with the Center for Industrial Production (CIP), Manufuture.dk has initiated the project: Manufacturing 2025 for the purpose of:

- [formulating an ambition for manufacturing in 2025](#)
- [developing scenarios of future manufacturing for a number of archetypal Danish manufacturing companies](#)

The future scenarios will contribute to defining the direction for manufacturing development and will, on this basis, point towards relevant research and development tasks. The scenarios will also form the basis for formulating a coherent Danish research initiative in the manufacturing sector.

## Organisation

Manufuture.dk has functioned as a steering group for the project. The project has revolved around a panel of company representatives, researchers from the three technical universities in Denmark, and two labour marked organisations (the labour or-

ganisation CO-industri and the confederation of Danish Industries).

The participating companies have in turn hosted workshops, which have typically been conducted over a period of eight hours, often with the participation of and input from specially invited national and international experts with experience relevant to the themes of the workshops. The workshops have also been supported by various relevant experts from the participating companies.

A small working group consisting primarily of researchers from Aalborg University has been formed in order to process the input from the workshops. Also, the workshops have been facilitated by researchers from Aalborg University.

The project has been funded partly by the participating partners and partly by a grant from the Danish Agency for Science Technology and Innovation. A list of all partici-

pants in the project and their organisational affiliation can be found in Appendix 1.

## Process and progression

In order to include as many viewpoints as possible in the considerations, five workshops on different themes have been conducted, and a 'model' for the workshop process has been developed.

The workshops have been aimed at a topical progression, which has often started by uncovering the 'state of the art' within the theme of the workshop and then progressed to extend the professional perspective in terms of time and the degree of technological "forecasting". The time horizon of the discussions has been 2025. This time horizon was chosen on the basis of two main perspectives:

1. [To liberate participants from everyday life and its problems, thus enabling them to think in new and 'ideal' ways](#)

2. To choose a realistic time horizon which participants can relate to and which is somehow realistic despite the desire to think in a long-term and ideal manner

In support of the structure and as a catalyst for discussions, a number of generic cases were developed for each workshop. The cases were based on three archetypal companies: The focused manufacturing company, the integrated manufacturing company, and the network-based manufacturing company<sup>9</sup>. The cases have contributed effectively to concretising participants' discussions and recommendations.

## Themes

Each workshop has focused on a theme. Below is a short description of the themes:

1. Conditions for future manufacturing – creating a common working basis and formulating ambitions and themes for subsequent work

2. Variation vs. costs – focusing on how to increase diversity without increasing costs

3. Sustainability – developing systems, products and structures that accommodate reduced CO<sup>2</sup> footprints to the highest extent possible

4. Flexible localisation – accepting global manufacturing but focusing on knowledge sharing and gathering

Between the workshops, the working group has collected all presentations, discussions and viewpoints and drawn up a summary that has functioned as a starting point for the following session.

The fifth workshop was used for summarising the entire process with the focus on developing a number of general scenarios of future manufacturing systems.

The entire process has taken 12 months. The duration and the large team of continuously associated persons from companies,

universities and organisations have enabled the creation of a cohesive and increasingly profound dialogue across workshops and themes.



# Challenges towards 2025

There are no quick-fix solutions available. This work is critical towards some of the traditional responses to the challenges that Denmark is facing.

This means e.g. that:

- a. Automation is necessary, but it will not solve the problem on its own. The entire manufacturing set-up must be developed.
- b. Productivity is necessary but will not solve the problem on its own. It is the 'efficiency' that must be increased in order to achieve value creation.
- c. Ingenuity and creativity are necessary, but innovation emerges with – rather than independently from – manufacturing.

Denmark's situation is also characterised by a number of structural challenges. The majority of Danish manufacturing companies find it difficult to compete with large global companies in terms of basic technology development. Several surveys<sup>10</sup> indicate that Danish exports are based

on 'low-technology products' to a larger extent than is the case for similar small OECD countries.

## Changed market and competitive conditions

Apart from this, Denmark is also subject to the general global market trends, which indicate that conditions for manufacturing in Western countries in the coming 10-15 years are expected to become more difficult in several respects, of which some of the most important are:

1. Increasing market logic and reduced protectionism
2. Increasing and intensified search for comparative competitive advantages
3. Speed is an increasingly important competitive factor coupled with growth and increasing profits as driving forces

The environment, energy and resource problems will play even more important roles in the future – both practically and

politically. There will be increased scarcity of important resources along with political regulation aimed at promoting sustainability. We are thus facing challenges that require highly ambitious new solutions.

## Three key challenges and ambitions

In the project, three concrete challenges and ambitions for manufacturing in 2025 have been identified, and these have served as focal points of the workshops.

### Diversity vs. costs

**Challenge:** Diversity of products and technologies must be cost neutral in 2025. The technology used today causes that high-volume standardised production to be more cost efficient than low-volume flexible manufacturing.

**Ambition:** Unit costs are independent of volume, and at least a fivefold increase in manufacturing responsiveness.

## **Flexible localisation**

Challenge: There is a risk that Denmark's manufacturing competences and product development ability are eroded as manufacturing is globalised.

Ambition: Knowledge sharing and integration must function despite geographical and cultural challenges in order to retain competences. Also, production and delivery systems must be so flexible that the mix of decentralised/centralised manufacturing is sustainably neutral.

## **Sustainable vs. conventional production**

Challenge: In 2025, businesses will face increasing demands with regards to sustainable design and manufacturing, while the requirements for competitiveness and efficiency will continue. In all respects, sustainable production must be able to outperform conventional manufacturing as we know it today.

Ambition: The carbon footprint of manufacturing by 2025 must be zero, and costs must be lower than those of conventional manufacturing.

At the same time, product lifetime must be doubled, and customers must continually be offered new facilities and functions.

The challenges and ambitions thus formulated play a key role in the concrete design of the five scenarios of future manufacturing.

# Five future scenarios of Danish manufacturing

The ambition of the working group has been to develop a number of future scenarios enabling manufacturing in a Danish context in 2025. This has resulted in five future scenarios – or 'models':

- a. [The highly competent manufacturing company](#)
- b. [The industrial power centre](#)
- c. [The innovation factory](#)
- d. [The flexible value chain integrator](#)
- e. [The virtual business](#)

The five scenarios address the given challenges and ambitions – and focus in different ways on the need to develop production, productivity and the Danish framework surrounding the manufacturing sector.

## The solution space

It has not been the intention of the 2025 group to present a final solution to the challenge that Denmark is facing. Undoubtedly, it is quite possible to develop other solution models than the five that the 2025 group have arrived at. Also, the scenarios can presumably be interpreted and construed in more ways than one.

The five scenarios are rather intended to open up a new and innovative solution space which can subsequently form the basis of a constructive and open debate among the stakeholders involved: industry, industrial organisations, institutions of education, politicians, etc. The scenarios may perhaps also contribute to a strategic and innovative process in Danish businesses and thus provide a source of inspiration for the development and strategic direction of individual businesses.

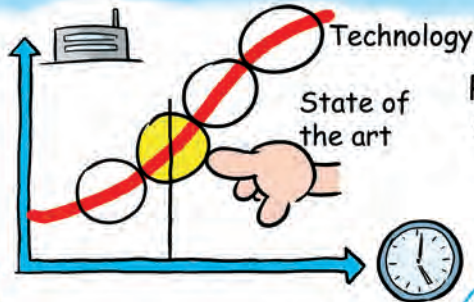
## The future scenarios

The five future scenarios are generic; they can inspire each other and be combined in numerous ways.

The scenarios are also generic in the sense that they are realisable in all types of industries. Each of the five scenarios appeals to companies of different sizes and at different technological levels whose strategic situations are different in terms of markets, competencies, resources and capital.

In the following, the models are described in detail.

# The highly competent manufacturing company



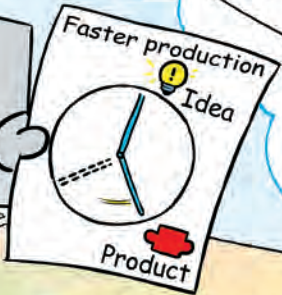
Perfectly timed application of new knowledge leads to competitive advantages

Dos and don'ts in relation to requirements and markets

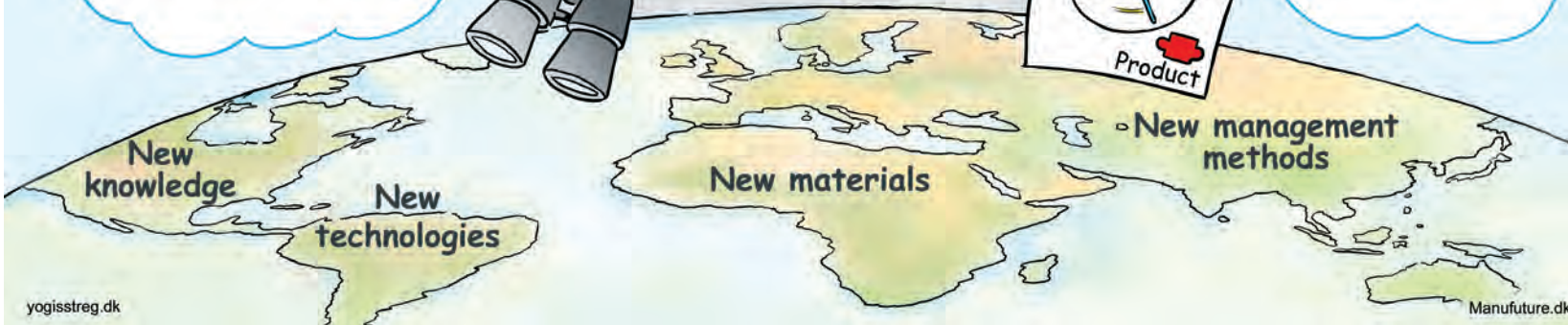
Spotting new technologies and implementing them rapidly - before others do so



We deliver quickly - again and again



New management methods



# The highly competent manufacturing company

Many analyses indicate that Denmark is trailing behind in terms of product and productivity development and Denmark is currently at the bottom of the list of OECD countries<sup>11</sup>.

Danish manufacturing companies have a very large and unexploited potential, which can be tapped using existing technologies and knowledge. There is a gap of at least 10-15 years between 'the leaders' and the majority of Danish companies. If this gap is closed, Danish manufacturing companies will be promoted to the league of 'world-class' manufacturers.

## The technology exists

Danish manufacturing companies must strive to be among the best at exploiting new technologies developed by other countries and at developing new products.

The technology, knowledge and examples of its application already exist, but Danish manufacturing companies must become better at spotting the right technology and

both quicker and better at implementing it than is the case today.

The trick is to spot a new technology in the window between what is referred to as the 'early adopters' – the very first companies that exploit the technology and therefore also run a certain risk – and the 'early majority' that are among the first industrial users when the technology is more mature and the risk correspondingly lower. If you end up among the 'late majority' or the 'lag-gards', it is too late.

This requires management focus and skill at all levels of the company. At the same time, it requires an effort by knowledge and research institutions to be at the cutting edge of the latest knowledge.

There is, however, no reason why Danish companies should not start already today.

## Knowledge gaps for discussion

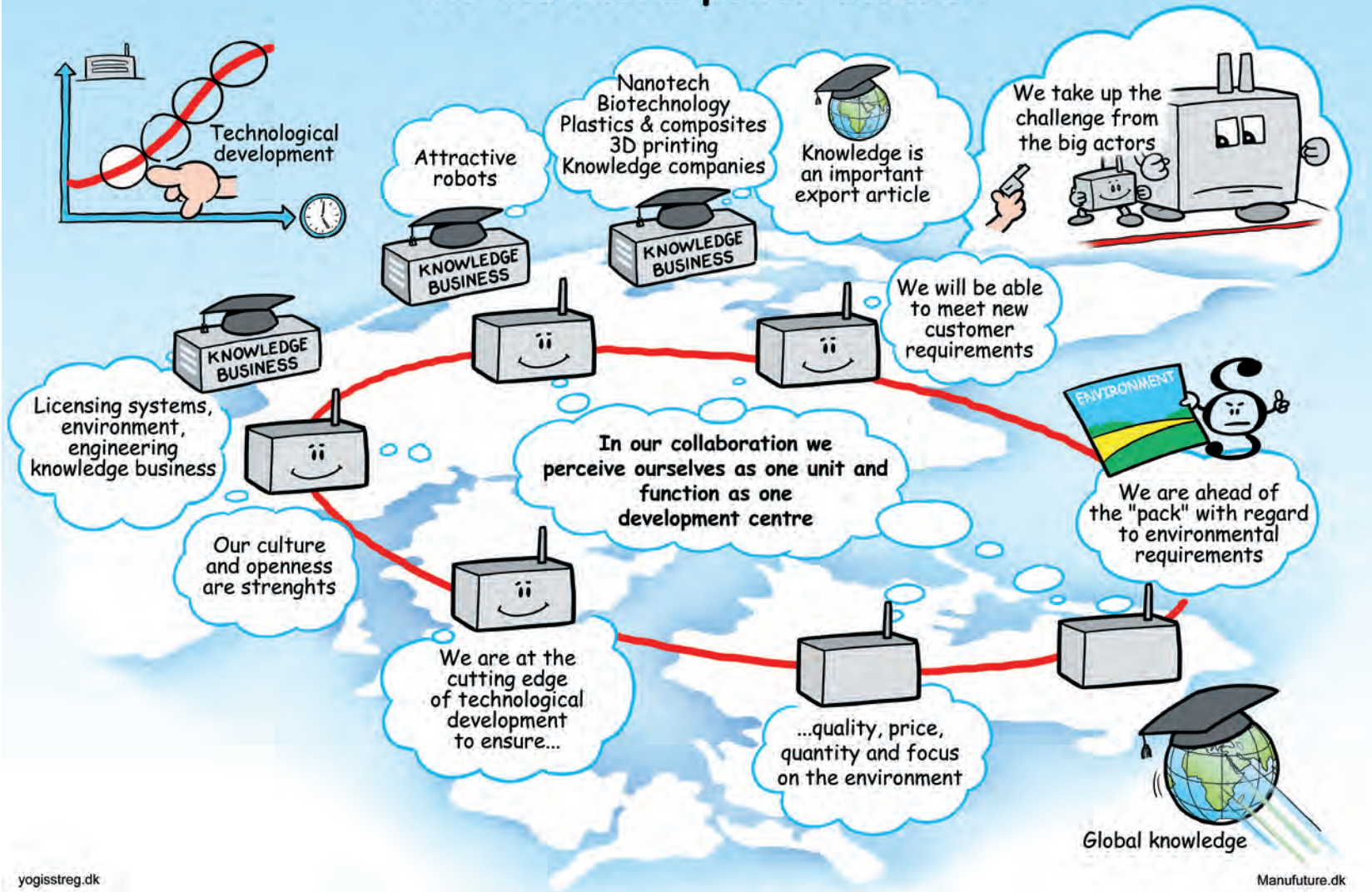
### Education:

- Strengthening of general as well as specialised manufacturing education in Denmark
- Continuous education in internationalisation of managers and integration of strategic and technological competences

### Research:

- Optimise the knowledge acquisition and applications research of universities to suit Danish conditions
- New methods and theories of employee-inclusive implementation

# The industrial power centre



# The industrial power centre

Even large Danish manufacturing companies are dwarfed by the size of international companies. At the same time, they are subjected to relatively more restrictive conditions of manufacturing than manufacturers in other countries, e.g. high costs and strict environmental and energy requirements.

The size of Danish manufacturing companies generally means that they are too small to develop new technology. On the other hand, Danish companies are very open to solutions developed in other countries and towards both national and international co-operation.

## Take up the challenge

The industrial power centre consolidates and coordinates competences and resources across businesses, industries, universities and knowledge centres to take up the challenge presented by the technological leadership of large international manufacturers.

The industrial power centre must contribute to the solution of two problems:

- a. Contributing to the technological leadership and global competitiveness of Danish businesses, thereby retaining jobs in Denmark
- b. Developing advanced technology and knowledge that support the solution of the former problem and are also exportable

By focusing on new user requirements and new manufacturing technologies, the power centres can enable companies to solve problems across individual industries.

This applies to e.g. engineering in connection with new materials and composites, aiming at introducing them earlier into the manufacturing systems of Danish businesses, or development of new energy-saving production processes.

Danish businesses enjoy the advantages of geographical proximity, a common language, and a shared culture – not least in terms of learning quickly.

## Knowledge gaps for discussion

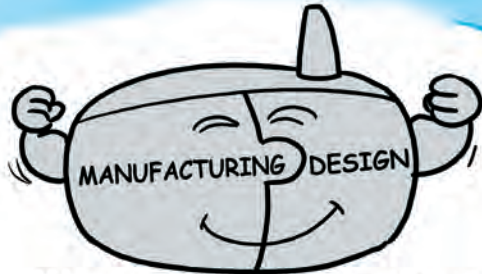
Education:

- Continuous education in network and technology network management

Research:

- Establishment of research and development projects such as EU framework programmes and high-tech projects, e.g. within sustainable manufacturing systems, hyperflexible manufacturing, and modular and intelligent manufacturing systems
- Research on the organisation of knowledge development in networks

# The innovation factory

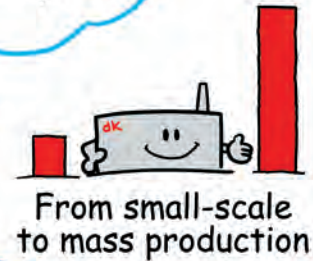


We are good at cultivating and optimizing the interplay between production and design competences



Employees' knowledge of business, design and production processes play an important part

Launched on the market while still profitable



Knowledge generated outside is used at home





# The innovation factory

The Danish workforce and the organisation of the labour market are more strongly oriented towards problem solving and learning than many of the countries with which we normally compare ourselves<sup>12</sup>. At the same time, Denmark as a nation is open, cooperative and positive towards globalisation<sup>13</sup>. Considering that much innovation of companies comes from external sources (suppliers, customers, etc.), this may provide Denmark with a competitive advantage<sup>14</sup>.

## Focus on the interplay between manufacturing and innovation

The innovation factory cultivates and optimises the interplay between design and manufacturing competences in order to develop 'intelligent products' for customers and accelerate time-to-market. Advanced manufacturing methods such as prototyping and ramp-up are applied to support and accelerate the innovation process.

Danish manufacturers function as a 'launch pad'. The business is focused on niche production with high contribution margins and

gives up production when 'cost' becomes the decisive factor. Manufacturing is perceived as a knowledge container and is evaluated equally on cost and knowledge contribution. Thus, all employees of the business contribute to the innovation process in their own right.

The company possesses the knowledge to decide when innovation and production should be transformed from small-scale to mass production and low-wage areas. Managerial focus is on organising learning loops to ensure that knowledge from outsourced production can be used in the innovation factory.

## Knowledge gaps for discussion

### Education:

- Upgrade all employee categories to ensure a higher degree of involvement in design and manufacturing processes
- New specialised programmes providing design and innovation competences
- Business understanding, design and innovation as basic competences in market and development departments

### Research:

- Explore relationships between design and manufacturing knowledge building, innovation, and product development processes
- New business-based assessment systems (metrics) that support knowledge building in manufacturing systems rather than standard cost models

# The flexible value chain integrator

Our knowledge of business and technology enable the big players to make money

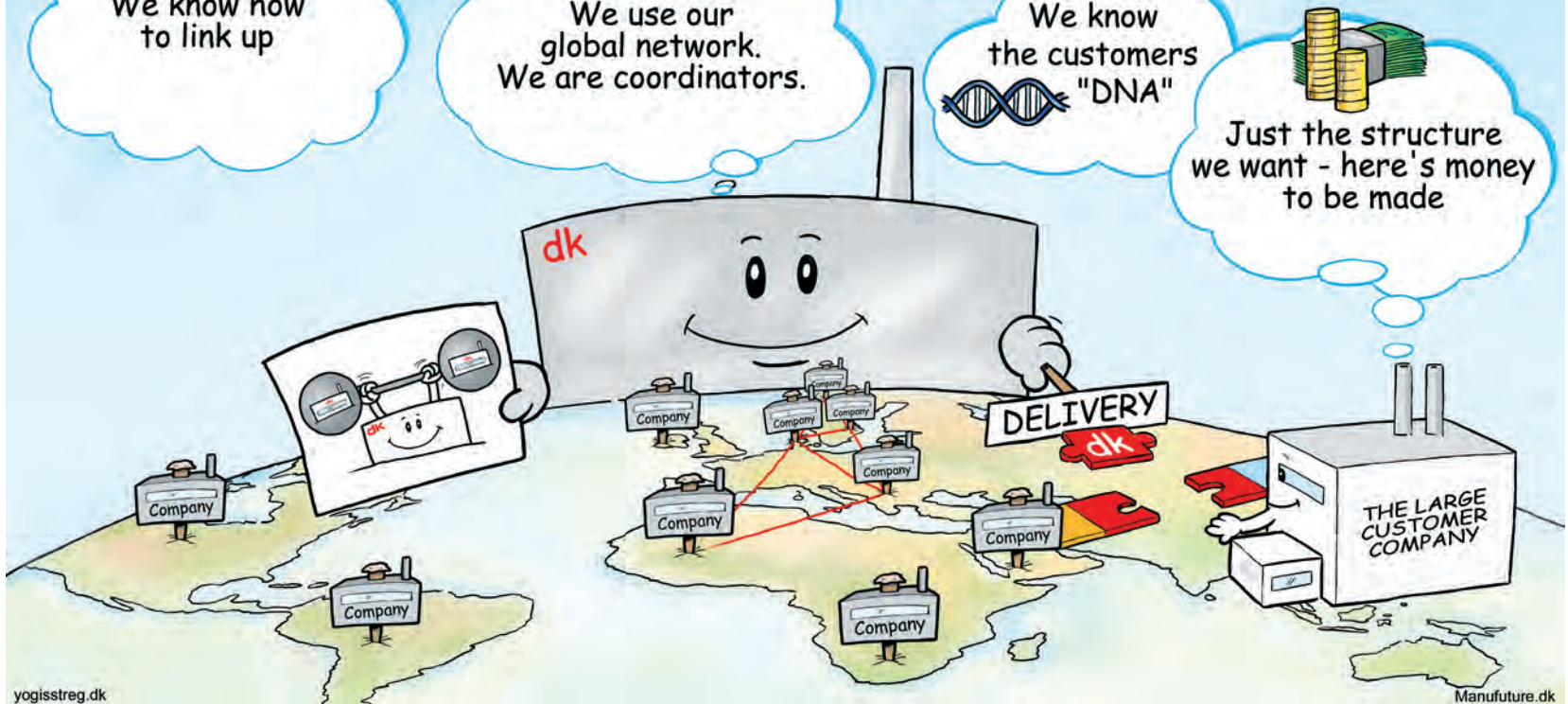
We can provide the flexible "building blocks" that the big boys need

We know how to link up

We use our global network. We are coordinators.

We know the customers "DNA"

Just the structure we want - here's money to be made



# The flexible value chain integrator

Danish industry mainly consists of small and medium-sized manufacturing companies, many of which function as flexible subcontractors focused primarily on neighbouring markets due to their size and resources.

The problem for many of these companies is that despite possessing a high degree of competence in their fields, they are unable to meet the requirements of large international customers on their own<sup>15</sup>. They do not have access to a network of cooperating partners complementing their special competences, and they do not have sufficient capital or orders to maintain specialist competences.

Great opportunities for Danish subcontractors if they learn to cooperate in networks.

## Focus on international OEMs

The central idea of the model is to build a network of suppliers supported by global flexible value-chain integrators that understand how to integrate with international

original equipment manufacturers (OEMs) with regard to business and delivery.

A competence is build of configuring 'value constellations', which are composed by a number of small subcontractors. The value chain integrator creates an environment of special competences, thus 'lifting' small subcontractor businesses onto the global market.

The flexible value chain integrator can compose any type of value delivery to fit into the value chain of a given OEM. This also applies to the need for new solutions in terms of components, additives and processes for the end delivery of the OEM as well as more complex system deliveries.

## Knowledge gaps for discussion

### Education:

- Continuous education in business development and management of network

### Research:

- Development of methods and theories of optimising/restructuring and creating increased value in complex value chains
- Integration of OEMs and the 'production systems' of small suppliers
- New forms of organisation and cooperation

# The virtual business



We exist as one business for as long as we cooperate on the product

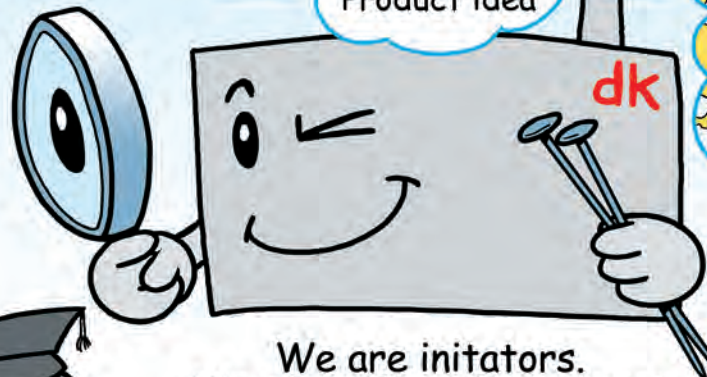


We create our business together

Product idea



New project cooperation



We are initiators. We identify and construct good network cooperation

# The virtual business

The Danish economy is a very open economy. Danish companies are generally very experienced in international cooperation and trade, which is reflected in the fact that Danish foreign trade represents about two thirds of our total GNP. Denmark is perhaps rather a nation of “shopkeepers” than scientists.

The international trade experience of Danish companies and their ability to spot new business opportunities can be exploited to a higher degree. This requires methods of mobilising sufficient resources and competences to implement ideas.

## Focus on global competences

The virtual business connects the best global competences in virtual networks in order to quickly and effectively exploit more business opportunities and pool its resources of business creation, innovation, distribution, and production.

Using this model, companies will be able to continuously configure new virtual busi-

nesses across borders, geographical boundaries, and cultures. The virtual business emerges in the interface between a number of independent legal entities, which 'own' the business together. The virtual business exists for as long as the product exists or a profitable business can be created. Profit and risk are shared among the members of the network.

For many Danish manufacturing companies, integrating to become part of a larger shared but loosely connected and constantly changing network would be a significant new step. It will require substantially different forms of cooperation and methods of integration. It will also change control of the business and the HR area, in which employees may be more loosely attached to the businesses.

## Knowledge gaps for discussion

### Education:

- Management and HR related to employee mobility between businesses

### Research:

- Development of ICT-based modular platforms enabling Plug/Play integration of cooperation forms
- Explore the concept of 'the virtual business', including technology enablers, culture, etc.
- Explore network cooperation and the concept of 'intelligent' modular supply chains



# Continuous dialogue on the knowledge requirements uncovered by the five future scenarios

A strong and comprehensive effort is required from individual companies, society, and industrial organisations in order for Denmark to be able to maintain manufacturing as an important sector.

The five future scenarios can be used as a starting point for discussing how to meet this challenge. With each scenario, guidelines are provided as to requirements for development and communication of knowledge in order for the framework of production conditions to best accommodate the five scenarios.

## Research catalogue

On the basis of the knowledge requirements indicated for each of the five future scenarios, the 2025 group has drawn up a comprehensive catalogue of concrete efforts required within manufacturing research.

The catalogue – which is published separately – identifies a number of concrete areas in which research and development efforts are required in the coming years. A strengthening of these areas will improve and develop

Denmark's manufacturing competence. It is therefore necessary to allocate means to finance this research and development, and there is a need for developing instruments to increase cooperation between universities and between universities and Danish industry.

## Cooperation between industry and universities

Industry and the individual companies also carry a great responsibility. It is important for each individual company to have a high level of ambition and persistently pursue its goals, e.g. through continuous competence development.

In this regard, a number of Danish manufacturing companies – including small and medium-sized businesses – would benefit from cooperating more closely with knowledge centres and universities. Likewise, such cooperation would also benefit the research, teaching and study programmes of universities.

The five future scenarios may help form the basis of a dialogue on cooperation and development of new knowledge and competences. The Manufacturing 2025 group intends to use the future scenarios and would enjoy participating in further dialogue in this respect.





# Appendix 1: List of participants

The following persons have participated in the project and contributed to the creation of the five scenarios:

## Danfoss:

Hans Christian Orye, Jesper Høyer, Lars Finsen, Lars Vorm, Morten B. Sørensen, Peter Johansen, Søren Lauridsen, Torben Sindberg

## Danish Crown:

Søren F. Eriksen

## CO Industri:

Arne Jensen

## Confederation of Danish Industry (DI):

Henrik Valentin Jensen

## Technical University of Denmark (DTU) Management:

Per Langaa Jensen, Martin Grunow, Renzo Akkerman

## Grundfos:

Jacob Dirks, Jacob Nielsen, Jeppe Drachmann Christensen, Johnny Overgaard, Klaus E. Christensen, Rikke Landlyst Groth, Søren Møller, Torben Buch Rasmussen

## LEGO:

Chresten Bruun

## Robocluster:

Niels Jul Jacobsen, Bruno Hansen

## University of Southern Denmark (SDU),

## The Maersk Mc-Kinney Moller Institute:

Henrik Gordon Petersen

## Danish Technological Institute – Danish

## Meat Research Institute (DMRI):

Keld Mønsted, Lars Hinrichsen

## Terma:

Henrik Christensen, Jesper Freltoft

## Aalborg University (AAU), Center for Industrial Production (CIP):

Anders Vestergaard, Jens Ove Riis, John Johansen

## Aalborg University (AAU), Department of Architecture, Design and Media Technology:

Christian Tollestrup

## Aalborg University (AAU), Department of Mechanical and Manufacturing Engineering:

Ole Madsen

The following persons have given presentations at project workshops:

## Asger Daugbjerg

Huset Mandag Morgen

## Jørgen Steen Nielsen

Dagbladet Information

## Ton van Keken

InterfaceFLOR (The Netherlands)

## Jan Sjögren

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## Lutz Oliver Schapp

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## Anders Hedegaard Petersen

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## Sources

1. Nationalbankens kvartalsoversigt, 1. kvartal 2010
2. Ingeniøren, 27 March 2010
3. Børsen, 3 June 2009
4. Manufuture, 2006
5. 'Sådan ligger landet', DI, April 2010
6. FuTMaN - The Future of Manufacturing in Europe 2015-2020, March 2003
7. Jyllands-Posten, 24 June 2009
8. Produktivitetseffekter af erhvervslivets forskning, udvikling og innovation. Innovation: Analyse og evaluering 1/2010. Forsknings- og Innovationsstyrelsen
9. Inspired by 'Interaktive virksomheder, Dansk Industri & Center for Industrial Production, AAU, 2004'
10. Dalum, in 'Fremtidens produktion i Danmark', 2004
11. Industrien, Jyske Markets, 3 March 2010
12. DRUID Working Paper No. 04-04
13. 'Sådan ligger landet', DI, 2010
14. Linder, Jarvenpaa and Davenport, Sloan Management Review, 2003
15. Nyt innovationsnetværk for underleverandører i vindmølleindustrien, Metal Supply, 17 March 2008

Fig. 1 Statistics Denmark

Fig. 2 Statistics Denmark and calculations by the Danish Confederation of Industry

