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White papers for a green transition

CIRCULAR ECONOMY

Denmark as a circular economy solution hub

INSIDE THIS WHITE PAPER

Designing products for the circular economy
Circular economy principles in the design process

New circular economy business models
To promote more sustainable production and consumption

Looping resources
In a circular economy, waste is a resource



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Denmark as a circular economy solution hub

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EXECUTIVE SUMMARY

This white paper has the purpose of contributing to the common understanding of the concept of the circular economy and, through practical examples, illustrating how Danish companies are providing solutions that help progress the transition towards a circular economy.

Circular economies are high on the international political agenda. However, we are only at the beginning of the journey towards becoming a circular economy. Public and private co-operation is crucial in converting challenges into opportunities at a national, regional and global level. Danish companies are already moving towards adopting more circular business models because it has proven to be a sound business strategy that facilitates access to new markets, drives innovative solutions and saves production costs. Circular economies are highly business driven. Throughout this white paper, specific company examples will be used to exemplify and show how new innovative business models can benefit the environment, climate and economy.

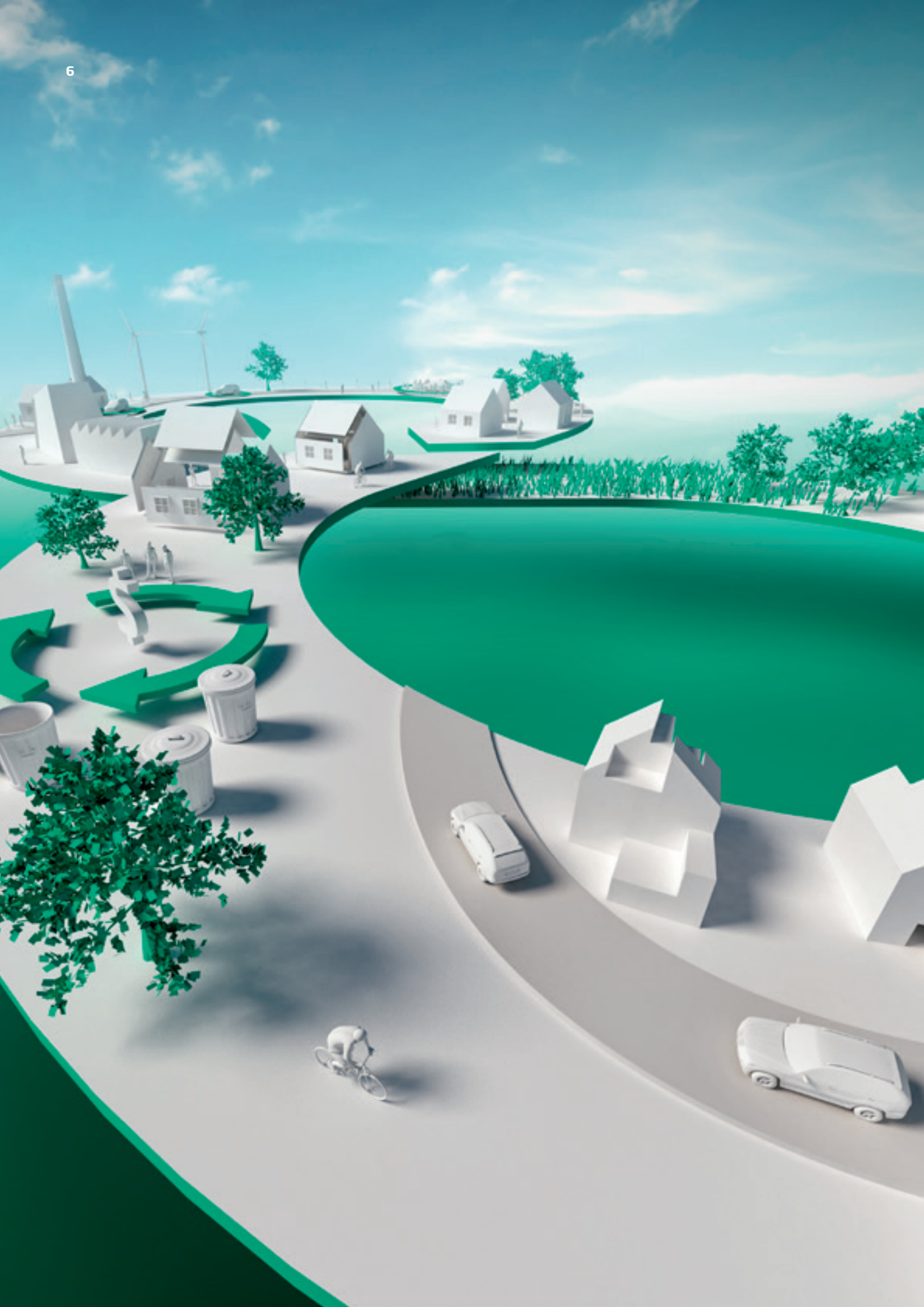
Chapters 1, 2 and 3 start by looking at the concept of the circular economy and new types of business model, before diving deeper into how the design phase of products can provide circular economy solutions. For the materials that cannot be reused, high quality recycling can transform these materials into valuable secondary raw materials - this is looked at in chapter 4. Chapter 5 looks at resource efficiency and partnership between different sectors. Chapters 6 and 7 have a sectorial focus on the bio and construction industries, and chapter 8 explores the potential of a circular economy.

Hopefully this white paper will inspire others to progress the transition towards a circular economy.



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FOREWORD

Circular economy challenges us to rethink the way we design, produce, consume and dispose. Circular business strategies provide economic and environmental opportunities that are too great to be missed.

*Rasmus Jarlov, Minister for Industry, Business and Financial Affairs
Jakob Ellemann-Jensen, Minister for the Environment and Food*

Circular economy is an important agenda for business, societies and politicians – an agenda which is here to stay and is a priority for the Danish government. If we do things right, circular economy can deliver key environmental benefits and at the same time significantly strengthen our businesses by reducing costs and creating jobs. Therefore, the Danish Government has recently published a Strategy for Circular Economy. The strategy has six main themes that assume that SMEs must be the driving force in a conversion to the circular economy over data and digitization into the actions that can be taken within the value chain. There is also focus on design initiatives, new sustainable consumption patterns and an effective market for recycling of waste and secondary raw materials. Finally, the Government focuses on initiatives supporting the circular economy of biomass and construction.



Rasmus Jarlov, Minister for Industry, Business and Financial Affairs

Denmark wants to be among the leaders in unleashing the potentials of a circular economy. And the good news is that Denmark has already begun. Many Danish companies have spotted the advantages of “going circular” and are delivering circular economy solutions to the global market. Companies from large multinationals to the smallest start-up companies are already now picking up on the advantages of a circular thinking. We invite you to seek collaboration with them to accelerate your transition to become circular.

The way to harvest the economic, social and environmental potentials of circular economy is to embrace the entrepreneurial, innovative, and economic force of the private sector. The Danish government is committed to promote circular economy by providing conditions that can nourish this development. We want to engage in a close dialogue with the business sector to help overcome barriers and we want to ensure good framework conditions for companies that want to move towards a circular economy. The Danish government’s commitment to going green focuses on a balanced approach that considers both the environment as well as ensuring competitive conditions for growth and jobs. This is among other things done by a mix of business friendly policies and opening up markets for competition, all in a way that makes going circular a good business opportunity without huge public spending.

This Circular Economy White Paper presents and discusses some of the key elements of a circular economy. It clearly describes how businesses can gain value from circular economy through changing

product designs, inventing new business models, boosting resource productivity and increasing reuse and recycling. Most importantly, it demonstrates how numerous Danish companies are leading the way in providing circular economy solutions.

Denmark has a long tradition for being in the forefront working with green solutions and green technologies and we believe that circular economy is the right way to continue to create a more sustainable society for the future. In other words, circular economy is good for business, it’s good for consumers and it’s good for the environment. A classic win-win-win. We need to go there now.

We are pleased to share this Circular Economy White Paper with you. It is the first White Paper that provides insight into this important agenda supported by examples. We hope you will be inspired.



Jakob Ellemann-Jensen, Minister for the Environment and Food

1. FROM A LINEAR TO A CIRCULAR ECONOMY

Transforming our society towards a more sustainable path.

Danish companies are developing pioneering circular economy solutions that promote sustainable production, consumption and recycling through proven and reliable solutions as well as innovative business models.

The world population is projected to reach 9.7 billion by 2050. In 2030, the world's middle class consumers will number 3 billion more than in 2009. With an increasing global population and a significant increase in living standards around the world, the pressure on natural resources will be intensified over the next decades. However, these global challenges also provide opportunities for new ways of producing and consuming goods and services.

Danish companies are developing pioneering circular economy solutions that benefits the environment, climate and economy. Some companies are increasing resource efficiency and reducing their environmental footprint by reducing the use of minerals and raw materials, ensuring responsible sourcing of their raw materials and/or shifting consumption to renewable resources. Other companies are designing their products in such a way that the lifetime of the products is extended and materials or components can be reused and recycled at a high value in the economy. Also, new business models and technological innovations are changing behavioural consumption and production patterns e.g. by providing services or sharing, rather than selling products. For companies, these new types of business models bring new opportunities to safeguard resources e.g. by keeping the ownership of the resources. The companies do so because it saves materials and production costs, while the same time reducing their environmental impact.

What is a circular economy?

"A circular economy is one that is restorative and regenerative by design, and which aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles"

- the Ellen MacArthur Foundation.

The transition to the circular economy is a shift from the linear take-make-waste economic model to an economic model where the economic value of the resources is fully utilised and the burden on global natural resources is reduced. Ideally, all waste is prevented or recycled in a circular

economy. Products are designed in such a way that materials and components can be restored and re-introduced (looped) into the economy, from production and consumption to reusing, repairing, re-manufacturing, refurbishing and recycling¹.

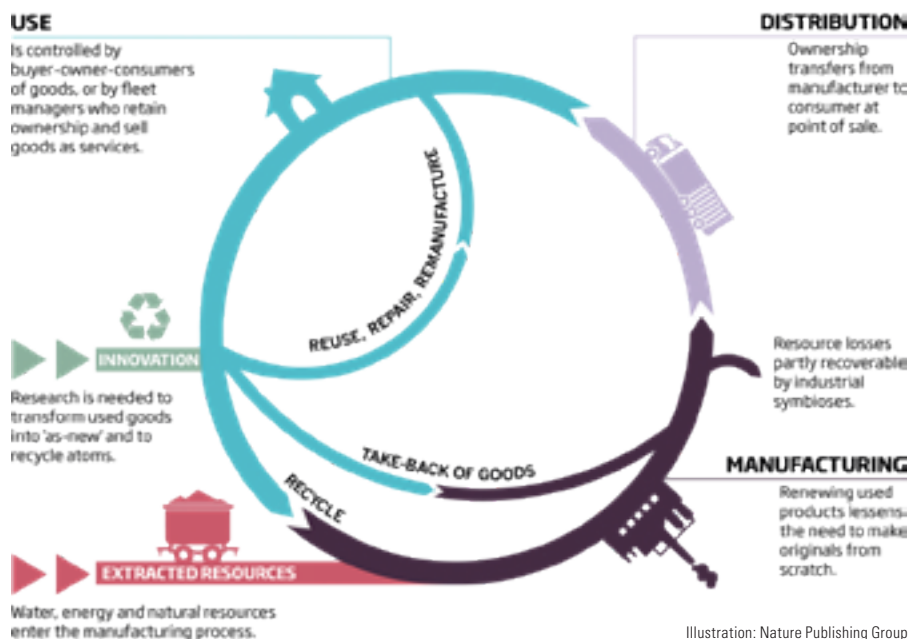
In transitioning to a circular economy, it is useful to distinguish between the technical and biological cycle. The technical

What is happening internationally?

In the EU, the implementation of a circular economy is high on the political agenda. In December 2015, the European Commission presented an EU Action Plan for a circular economy to stimulate economic growth and jobs. The action plan covers more than 50 initiatives aimed at leading the EU towards a circular economy². The circular economy also has a strong interlink-

CLOSING LOOPS

Using resources for the longest time possible could cut some nations' emissions by up to 70%, increase their workforces by 4% and greatly lessen waste.



materials are non-renewable fossil and mineral-based materials such as metals or plastic, and therefore the aim is to loop the materials in the economy for as long as possible in order to utilise their full value potential.

The biological cycle is renewable and characterised by the principle of cascading use. This means, for example, that biomass from agriculture, the food industry or forestry is treated in bio-refineries and valorised as nutrients that can be turned into new bio-based products in a number of value-chains.

age to the UN Sustainable Development Goals (SDGs) that are part of the UN 2030 agenda for Sustainable Development. A circular economy provides a profitable opportunity to reduce waste and move away from resource-intensive processes while maximising the use of existing assets. This will provide a positive contribution to the achievement of a number of SDGs such as goal no. 9 (Industry, innovation and infrastructure), goal no. 11 (Sustainable cities and communities), goal no. 12 (Responsible consumption and production), and goal no. 13 (Climate action). Around the world, countries are promoting the circular economy agenda, and the number

of circular economy solutions provided by companies are increasing rapidly³.

Why look towards Denmark?

Denmark has a long track record of environmental protection and transitioning towards a green and resource-efficient economy independent of fossil fuels. Denmark was one of the first countries in the world to have a ministry dedicated to the environment, which was established in 1971 and called the Ministry for Pollution Control. The green transition in Denmark is also highly driven by companies. The strong engagement from the business sector combined with ambitious environmental policies has put Denmark in a front-runner position with regards to the development of green technologies. Most Danish companies consider environmental concerns as a part of their license to operate, and they have shown that sustainability and economic growth can go hand-in-hand.

What is the economic potential for Denmark as the circular economy?

The Ellen MacArthur Foundation has conducted a number of studies of the potential of the circular economy. The Growth Within report from 2015 concluded that by adopting circular economy principles, Europe can take advantage of the impending

technology revolution to create a net benefit of €1.8 trillion by 2030, or €0.9 trillion more than in the current linear development path. This would be accompanied by better societal outcomes including an increase of €3,000 in household income, a reduction in the cost of time lost to congestion by 16% and a halving of carbon dioxide emissions compared with current levels. An extensive case study of the potential for Denmark as a circular economy was also carried out. The purpose of the case study was to deliver and test a toolkit for policymakers all over the world on how to unlock the economic and environmental opportunities in the circular economy. Denmark was chosen as a case due to its advanced and internationally recognised innovative initiatives relating to circular economy and sustainability. Yet there are still great economic opportunities to take advantage of in a further transition towards a circular economy. For Denmark, the modelling shows that in 2035 a transition to a circular economy within the following sectors: food and beverage, construction and real estate, machinery, plastic packaging and hospitals could lead to an increase in GDP by 0.8-1.4%, the creation of additional 7,000-13,000 job equivalents, a 3-7% reduction in carbon footprint, an up to 50% reduction in virgin resource consumption for selected

materials and an increase in net exports by 3-6%. If including all sectors, the potential for Denmark as a circular economy is even greater.

In 2015, Denmark was awarded the World Economic Forum's Young Global Leaders award 'The Circulars' for being a global front-runner in exploiting the potential for a circular economy.



The Ellen MacArthur Foundation and the CE100 network

The Ellen MacArthur Foundation was established in 2010 with the aim of accelerating the transition to the circular economy. Since its creation, the foundation has emerged as a global thought leader, putting the circular economy on the agenda of decision makers across business, government and academia. The Circular Economy 100 - CE100 - is a global platform run by the Ellen MacArthur Foundation, bringing together leading businesses, emerging innovators and regions to accelerate the transition to a circular economy. The platform provides a unique forum in which businesses can build circular capabilities, address common barriers to progress and pilot circular practices in a collaborative environment.



Photo: Ellen MacArthur Foundation

“Denmark is a long-standing member of the CE100 network. As a front-running nation within circular economy they are a valued member who readily share their best practices, bring innovative ideas to the table, and have been instrumental in helping the Ellen MacArthur Foundation develop its Toolkit for Policymakers.”

*Andrew Morlet, CEO,
Ellen MacArthur Foundation*

¹ Without recycling problematic and problematic chemical substances.

² Closing the loop - An EU action plan for the Circular Economy

³ Flash Eurobarometer of June 2016

2. DESIGNING PRODUCTS FOR THE CIRCULAR ECONOMY

Circular economy principles at the heart of companies' design processes.

Integrating circular economy principles in the design phase of a product is pivotal in making circular economy solutions profitable and sustainable. Danish companies are leading the way with their strong tradition for great design and innovative green solutions.

According to the European Commission, more than 80% of a product's environmental impact is determined in the design phase⁴. The design phase is therefore critical when creating new products for the circular economy.

In a circular economy, the design consequently needs to take account of a wider range of issues than in the linear economy. The design of circular products entails a full lifecycle perspective - integrating a second use phase, take-back systems, design for disassembly, reparability, reusability, recyclability, etc.

Characteristics of circular product design

The Ellen MacArthur Foundation has outlined key principles from which companies can generate value by incorporating circular design into their products and services:

- 1) reusing, refurbishing or remanufacturing products, parts and materials with as few changes as possible to keep value at the highest level
- 2) keeping products, components and materials in use for their intended use for as long as possible to generate most value from the products and parts
- 3) diversifying the use of products, components and materials to other purposes when they can no longer be used for their original purpose
- 4) using pure, non-toxic or at least easily separated inputs in products to minimise costs for recycling

Implementing these principles in the design of new products will challenge companies and their designers to think about fundamental issues such as:

- How can the business model be designed so that it captures most of the value in the materials used, e.g. based on secondary raw materials?
- How can the products be designed so that the product can be easily repaired and the product life extended, allowing for multiple use?

Danish design DNA is tuned to the circular economy

Danish designers and design firms are used to tackling the design challenges related to environmental factors in their work. The Danish design DNA, as it emerged from the "golden age" of Scandinavian modern furniture design in the 1950s, has always been characterised with a focus not only on quality, but also long-term sustainability. More recently, a diverse group of designers have committed themselves to the circular economy and are currently developing a unique Danish approach to some of the key considerations in designing for circular principles and upcycling. Themes such as sustainable and recyclable new materials: material upcycling: design for disassembly, design for ease of recycling, holistic design and aesthetic sustainability (long-lasting classic designs) are all in play amongst Danish designers.

Benefits from circular designs

A great circular design contributes to companies generating the most value from materials used in products and services as well as ensuring that materials are either circulated or regenerated after use. Experience shows that a good circular design can help companies save valuable resources, lower their production costs and create higher profitability. As mentioned, many Danish companies have a strong tradition for both durable and attractive design and sustainability, and they are now combining these capabilities to spearhead solutions for the circular economy. Example of a Danish company that have worked with circular design principles include the Carlsberg Group. The company have a long history of producing high-end quality products and have grasped the opportunities of a circular economy.

⁴ Ecodesign - Your future



Image: Carlsberg

Developing the world's first biodegradable beer bottle

One of the challenges the Carlsberg Group focuses on is packaging, as around 45% of their CO₂ emissions come from the company's packaging. They want to reduce this number by encouraging consumers to recycle more, minimise material usage and by developing new environmentally friendly packaging types. The Carlsberg Group have initiated a partnership with Danish company ecoXpac, Innovation Fund Denmark and the Technical University of Denmark to develop the world's first fully biodegradable beer bottle made from wood fibre - the Green Fiber Bottle. The bottle will be as

light as a PET bottle, while having the advantage of being created from bio-based sources. The project is one of the activities in the Carlsberg Circular Community, which is the Carlsberg Group's partnership platform to develop more sustainable products with partners from across the world. The community aims to eliminate the concept of waste by creating sustainable products and a more circular economy in an increasingly resource-scarce world.

Carlsberg Group, ecoXpac, Danish Technical University,
Innovation Fund Denmark

3. CIRCULAR CONSUMPTION THROUGH INNOVATIVE BUSINESS MODELS

New circular economy business models can promote more sustainable production and consumption.

In Denmark, both start-ups and more established companies have already introduced innovative circular economy business models to the market. The companies do so because it has proven to be a sound business strategy that facilitates access to new markets, drives innovative solutions, and saves production costs e.g. on resource input.

New types of business models are developing rapidly. There is no one-size-fits-all, which is why there is such a large variety of circular economy solutions being introduced. However, some trends, such as product-as-a-service and the sharing economy, are changing our production and consumption patterns.

Some companies are changing their business model from selling a product to selling a service. For example, VIGGA's business model allows parents to lease organic baby clothing instead of having to invest in new clothing. In general, these business models allow the company to retain ownership of the product (and thus also the resource) and keep the product in the loop for reuse, re-manufacturing and extension of its life-time. At the same time, the customer pays for the use and not the ownership of the products, which saves both money and resources.

A circular economy is highly driven by the digitalisation and platform models that allow consumers to share and utilise available resources and assets. A circular economy therefore has a strong link to the sharing economy, where the focus is on accessing products rather than owning them. For example, the Danish car-sharing platform GoMore allows travellers to share their ride or share their car with others. Even though not all sharing economy products and services are necessarily related to circular economy principles, the sharing economy has transformed consumer behaviour, and is expected to have an even greater influence in the future.

Consumption patterns play an important role in the transition towards a circular economy. Without a demand from the customer, the companies cannot sell their solutions. The public sector's significant purchasing power allows it to drive the demand for circular economy products and business models. For example, the City of Herning, located in Denmark, developed a guideline for reuse and circular procurement requirements for work clothing.

Another approach that can facilitate more circular procurement is using total cost of ownership as the basis for procurement decisions - i.e. not only considering the purchasing price, but also the operation, disposal costs and the potential future use and value. To help procurers calculate

the total cost of ownership, the Ministry for Environment and Food has developed a number of practical tools and guidance material that can be used in the procurement of different products, leading to more resource-efficient products and financial savings in the long run⁵.

These new business models benefit both citizens, the public sector and private companies by providing resource efficient solutions. For private companies, the new business models can help increase security of supply of resources, lower costs by reusing materials and pave the way for new business partnerships and markets. At its core, these new business models can save both resources and money.



Danish recycling station

⁵ The Total Cost of Ownership tools are available at www.csr-indkob.dk (only in Danish).



© www.vigga.us

A circular subscription concept

VIGGA was born as a circular concept. The idea was to create a new way of consuming, based upon sharing and circulating high-quality products.

Through a circular subscription concept, VIGGA offers high-quality children's clothes, produced under proper conditions, at an attractive price. This is possible because the same piece of clothing will be shared by several children and the quality of the clothing is so high:

- For a monthly subscription fee, the customers get 20 pieces of clothes in their child's size
- When the clothes become too small, they are replaced by new sets of clothes one size bigger

- After a quality inspection, the returned clothes are then washed professionally
- Subsequently, the clothes are delivered to another baby, resulting in a circular process

The concept creates an incentive for textile companies to produce in as high a quality as possible. The higher the quality, the more children can make use of the same piece of clothes and the higher the profit becomes. Furthermore, textile waste is reduced by 70-85%.

VIGGA

A circular travel solution

Cars are by far one of the most under-utilised resources in modern life. In Denmark, an average car transports 1.4 people on the road and spends about 23 hours per day taking up parking space. Empty car seats are the largest excess capacity in the transport industry, and this inefficiency has a negative impact on the environment and is expensive for car owners.

GoMore's platform offers a service that enables drivers to invite people for a ride on an already planned journey. This increases the number of people in cars and reduces the number of cars on the

streets, making car trips more efficient and better for the environment. It is a travel solution which is cheaper for both the car owner and the passenger.

Since GoMore was established in 2005, more than 1 million users have visited and used the service. As a result, more than 300,000 seats have been sold in Denmark alone, making GoMore a European leader in combining ridesharing and peer-to-peer car rental, and Scandinavia's leading business in the sharing economy.

GoMore ApS



Photo: GoMore

4. LOOPING RESOURCES

In a circular economy, waste is a resource.

A combination of regulation, ambitious target setting, focused business programmes and private commitments has put Danish companies at the forefront of European and global actors with regards to recycling.

Targeted regulation has been pivotal for Danish recycling rates

In 1978, Denmark introduced the world's first law on recycling, which stated that at least 50 % of all waste from beverage packaging and paper should be recycled. Then, in 1987, both a landfill and incineration tax was introduced, which in 1997 was supplemented by a ban on sending any waste suitable for recycling or incineration to landfills. Now, the EU's Waste Framework Directive lays out requirements for governments that regulations should give priority to waste prevention over other types of waste handling (the waste hierarchy). These important sets of legislation have started the Danish journey towards becoming amongst the top recyclers in the world.

In 2014, 67% of the total amount of waste in Denmark was recycled, while only 5% was sent to landfills.

Most recently, the Danish commitment to promote a circular economy is reflected

in the country's national waste strategy, "Denmark without waste"⁶. The strategy is divided into two parts, focusing on waste management and waste prevention, respectively. The waste management plan lays out quantitative targets for recycling as well as a large number of initiatives revolve around encouraging the development of green technologies, better waste policies and an increased focus on citizens and their role in the waste management cycle. The waste prevention programme highlights five different focus areas which are being addressed via 72 different initiatives such as encouraging resource and cost-efficient green business models as well as public-private partnerships.

Danish businesses at the forefront of recycling

One of the practical steps which have proven a significant influence on the rates for waste collection and recycling in Denmark is the Danish deposit-return system for beverage packaging. Targeted Danish legislation combined with

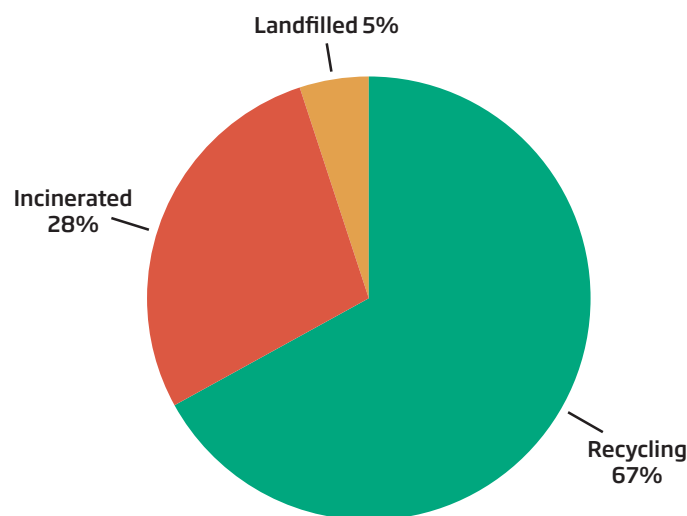
ambitious cooperation between private actors has meant that even though the amount of one-way packaging for beverages is increasing, the collection rate of this type of packaging remains stable at around 89 %, making it one of the most efficient collection systems for beverage packaging in the world.

Other areas such as recycling of construction and demolition waste, preparing hazardous wastes for recycling, treating contaminated soil and as well as commercial waste in general are also amongst the core expertise of Danish companies.

In addition, public programmes such as the Danish Green Investment Fund, Danish Eco-Innovation Program and Innovation Fund Denmark⁷ have supported the development of new technology for the circular economy and keep pushing Danish businesses towards adopting circular economy principles.

Recycled waste in Denmark

In Denmark approximately 11.7 million tonnes of waste is produced annually. In 2014 a total of 67 % of this was recycled, 28 % was incinerated and 5 % was landfilled.



Source: Affaldsstatistik 2014. Ministry of Environment and Food

⁶ Denmark without waste http://eng.mst.dk/media/mst/Attachments/Ressourcestrategi_UK_web.pdf
Denmark without waste II https://eng.mst.dk/media/164923/denmark-without-waste-ii_wasteprevention.pdf

⁷ For more information go to www.innovationsfonden.dk/en



Photo: Re-Match

Recycling of artificial turf

As the first in the world, Re-Match uses patented state-of-the-art technology to separate worn-out artificial turf into raw, clean components, which can then be re-used or recycled in the turf industry or in other industries. Re-Match is able to separate every part of the worn-out synthetic turf into rubber granules, sand and plastic fibres. The technology is so effective that almost 100% of the components can be either reused or recycled.

Each Re-Match facility can handle more than 40,000 tons of worn-out wet synthetic turf yearly, generating clean separated

materials, which are mainly reused in new soccer pitches world-wide. The process uses <20 tonnes of CO₂ per pitch.

On a global scale, 9000+ pitches will become waste in 2017. Previously, worn-out pitches were incinerated or sent to landfills. When incinerating a pitch, 340 tonnes of CO₂ is released. Furthermore, producing new raw materials for a pitch creates 80 tonnes of CO₂. Thus, by implementing a circular production process, a net CO₂ saving of roughly 400 tonnes per pitch is achieved.

Re-Match

Used insulation and discarded porcelain and sanitaryware upcycled into new insulation

With over 30% of Denmark's waste coming from construction, up-cycling of used building materials has become an area of increased focus. As a result, traditional disposal methods that send waste insulation to landfill sites and crush porcelain and sanitaryware to make road fill are being replaced by a new, greener alternative jointly developed by three Danish companies.

Construction waste from Danish recycling centres is delivered to RGS90, a company which specialises in the processing, sorting,

removing and recycling of waste products. Here, all unwanted materials are removed. Recyclable ROCKWOOL insulation and ROCKFON acoustic panels are then separated from the unrecyclable insulation before being granulated. Porcelain and sanitaryware are crushed before being sent to the ROCKWOOL production facility, where they are used to manufacture new, recyclable insulation.

This process was developed in 2012 by RGS90, ROCKWOOL and Combineering A/S



Photo: ROCKWOOL

5. RESOURCE-EFFICIENT PRODUCTION

Resource efficiency and industrial symbioses contribute to the circular economy.

Resource inputs make up a growing share of many companies' production costs, which makes efficient use of resources important to the companies' competitiveness.

In a world with finite resources and a still-growing global demand for raw materials, companies are rethinking their production processes and products in order to secure supply of resources, lower vulnerability and price fluctuations of resource inputs. Danish companies have seen great opportunities in increasing resource efficiency in their production processes or substituting critical materials with secondary materials, by-products or renewables, but also in developing new and innovative business models and new forms for co-operation.

There is no one-size-fits-all to a resource-efficient production. Some companies are focused on optimising and minimising resource use, e.g. through technological investments and Lean processes. In a circular economy, the focus is not only on 'doing more with less' but also to harness the full value of the resources, e.g. by extending the lifetime of components and materials.

Some companies are increasing resource efficiency by using materials from their own production processes or materials from returned products and components (e.g. through take-back-systems). This has resulted in companies starting to design their products and components so that they are easier to repair, re-manufacture and reuse. Other companies are engaging in new partnerships across sectors.

A circular economy demands new ways of thinking and new ways of co-operating,

both within and across sectors, in order to minimise the environmental footprint throughout the value chain, but also to develop new and innovative partnerships and solutions. A specialised form for partnership is an industrial symbiosis, where companies partner up so that one company's by-product can be used as a resource input in the other companies' production, turning one company's residue into another company's resource. As the world's first industrial symbiosis, the Kalundborg

Symbiosis, as well as other symbioses in Denmark, shows that there may be considerable economic and environmental benefits for companies that collaborate in such a manner.

Increased focus on resource efficiency has resulted in innovative Danish clean-tech solutions and expertise that are exported widely on the global market, such as energy-saving pumps and water-efficient solutions.



Distribution of expenses for selected industries, 2004-2012

Note: Calculated in current prices. Service consists of IT and business services. Material costs include expenses to raw materials and semi-manufacture while other costs, among others, include expenses to energy and commodities for onward sale.

Source: Statistics Denmark

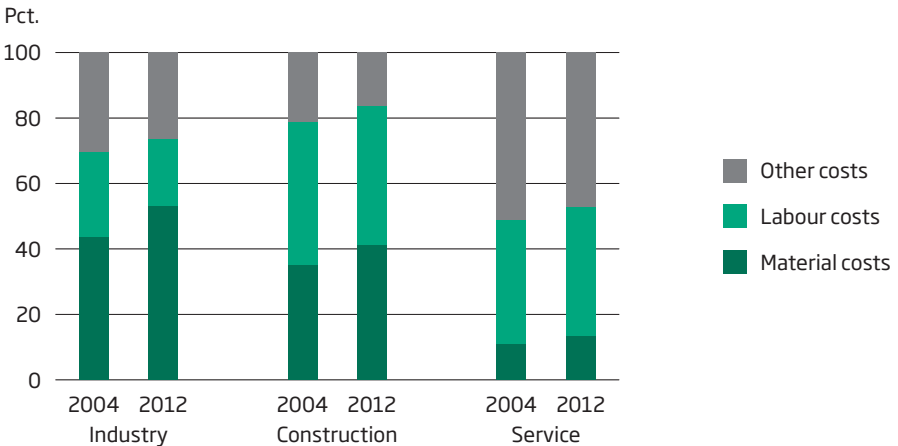




Photo: Grundfos

Grundfos pumps contribute to energy saving heating and cooling.

Pumps are one example of a type of devices used in many industrial applications. They play a vital role in dairies, breweries, slaughterhouses, textile and chemical production, power stations, shipping etc. More than 2/3 of all pumps installed today are inefficient and use up to 60% too much energy. Additionally, most pumps currently installed are larger than necessary and often run continuously at their maximum speed. Replacing inefficient pumps results in significant savings, reduces energy waste and thereby contributes to the circular economy by minimising the environmental footprint.

At the Yokohama Rubber factory in Japan, Grundfos switched out the main pump delivering water to cool the factory's production line. This enabled the company to drastically reduce energy costs by more than 50% while also contributing towards its commitment to reduce CO₂-emissions. Across Grundfos' own facilities, a flagship initiative has been running for several years now to replace all inefficient pumps and motors worldwide with high-efficiency Grundfos solutions. As a result, Grundfos' annual energy consumption has been reduced by more than 8.000.000 kWh.

Grundfos

Kalundborg Symbiosis - the world's first working industrial symbiosis

The Kalundborg Symbiosis is an industrial symbiosis, where a by-product or residual product of one enterprise is used as a resource by another enterprise. An industrial symbiosis combines the logic from nature's ecosystems with the rationales of the economic system. Through local collaboration, public and private enterprises buy and sell residual products from one another, gaining mutual economic and environmental benefits in doing so. Kalundborg Symbiosis started more than 40 years ago and is one of the most well-known and well-described industrial symbioses in the world. It has also inspired others to produce more for less. It is strongly connected to the creation of the first and only symbiosis

centre in the world, which works to identify and facilitate new industrial symbioses in Denmark. Kalundborg Symbiosis includes world-leading as well as smaller companies, but whatever the size, the benefits of industrial symbiosis are clear:

- Cost reductions and less emissions
- Growth for less resources
- More competitive enterprises
- More resilient societies and enterprises

Novo Nordisk, Novozymes, Statoil Refining, Gyproc, DONG Energy, KaraNoveren, Kalundborg Utility, Kalundborg Municipality and Symbiosis Center Denmark.

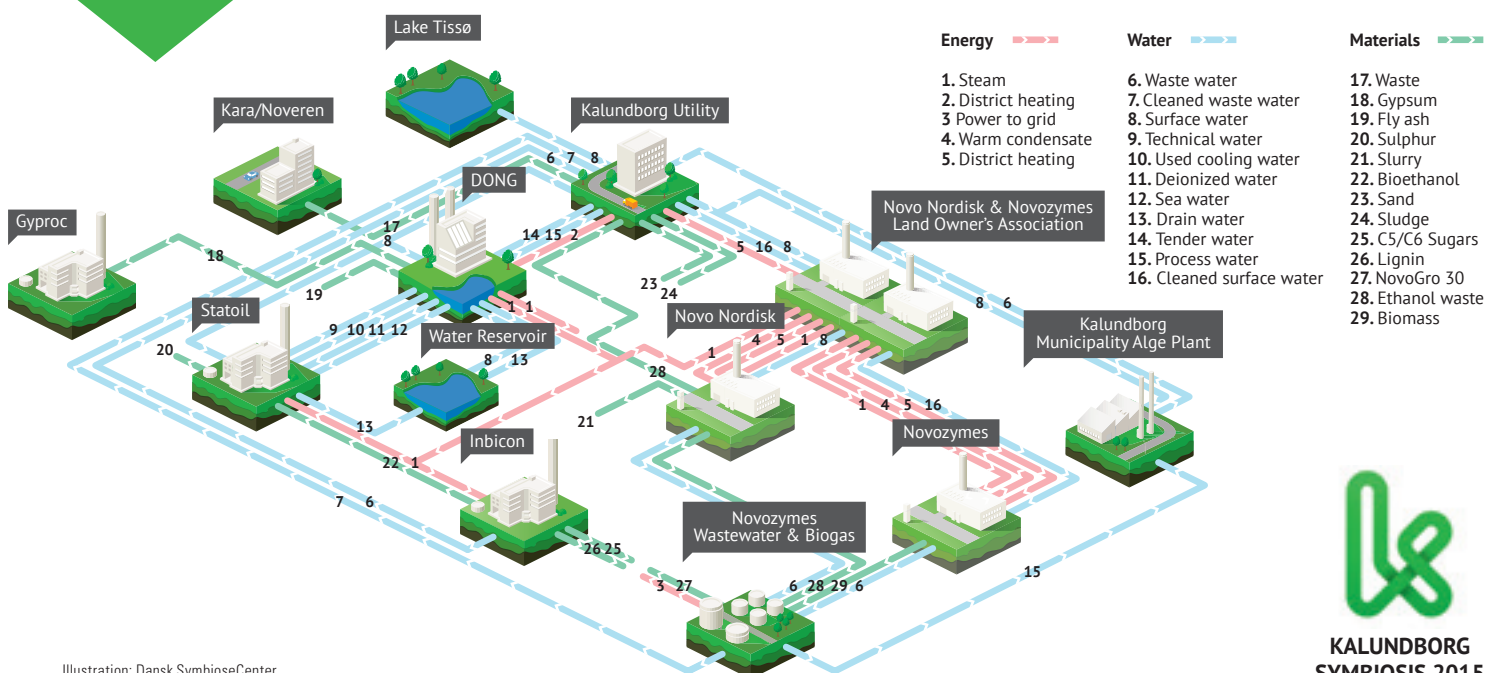


Illustration: Dansk SymbioseCenter



6. TURNING BIOLOGICAL SIDE STREAMS INTO VALUE

Bio-products from agriculture possess a great potential for recirculation.

The circular economy brings opportunities for better utilisation of side streams, and the Danish food industry cluster is an excellent example of this in practice.

The agricultural sector produces food as well as bio-products such as feed, fuels and renewable materials and returns the nutrients to the biosphere. New crops are grown by extracting the nutrients from the soil and carbon from the atmosphere, and new bio-products are produced in a closed loop.

Bio-products from agriculture possess a great potential for recirculation and are essential for transitioning today's fossil-based economy to a fossil-free circular economy. However, agriculture is not an inexhaustible source of biological feedstocks. Agriculture depends on fertile arable land, which is a limited resource. The challenge is to produce more food for a growing world population while at the same time significantly reduce the impact on the environment and climate.

Denmark has long demonstrated that this challenge can be overcome. Denmark is

among the world leaders in sustainable intensive food production. For example, the Danish pork industry has contributed significantly to this in the entire value chain. The key is maximising resource efficiency and minimising waste in every single step of the production, for example by replacing artificial fertilisers with manure, which is applied to farmland with low emission systems. Furthermore, the energy potential of manure can be harnessed by degassing it in biogas plants and turning slaughterhouse waste into bioenergy such as biogas and biodiesel.

The Danish agriculture & food sector is far ahead in terms of utilisation of side streams so that valuable substances are extracted before any residue finally is used for energy production. The principle is called profit-driven cascade utilisation or biorefining. The term cascading biorefinery covers the principle of increasing

value of side streams by splitting them into a number of fractions of different economic and biological value. One example of this can be found in the Danish potato processing industry, which shows how to increase the utility of potatoes. Nowadays, the industrial potato delivers much more than just starch since the residual potato fibers are transformed into a valuable protein-rich food additive. Moreover, Danish ingredient companies are at the forefront in demonstrating solutions and technologies that maximise resource efficiency and create value from side streams.

Across the Danish food production chain, more or less all companies are able to show profitable examples of how side streams can be transformed into new and valuable biobased products and materials.

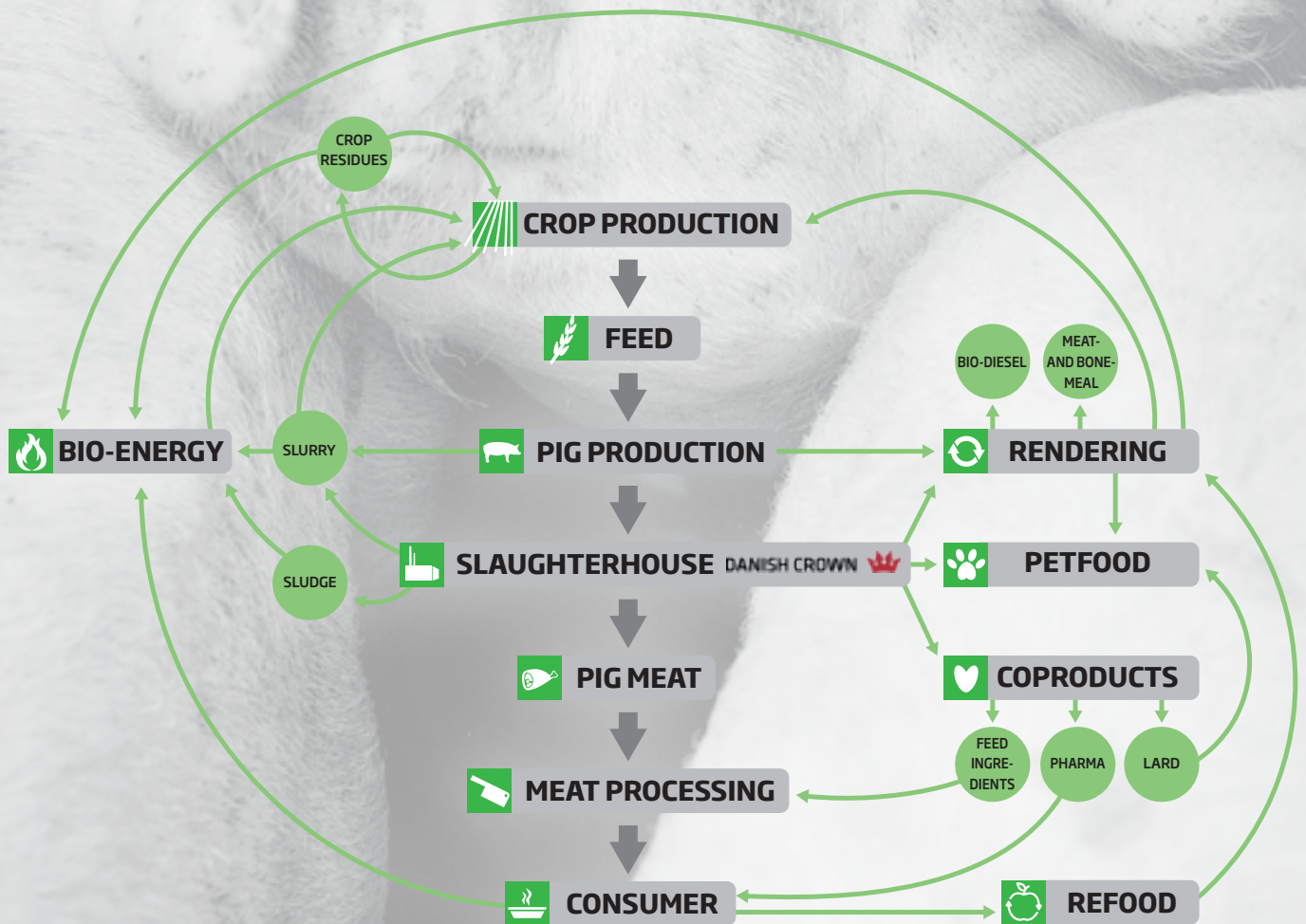


Potentials in potato starch production

Danish potato processing cooperative KMC, which produces a variety of potato starch ingredients for the food industry, has been a pioneer in adding value to its side streams. KMC is headquartered in central Jutland and operates a number of production sites in Denmark, staying close to its suppliers and owners, the potato growers. Since introducing potato-based feed proteins for the agricultural sector in the 1980s, KMC has advanced and refined the residuals of potato starch production. In 2005, KMC began

transforming residual potato fibres into a valuable protein-rich food additive for the food industry. Splitting and refining the side streams from potato starch production helps maximise output of each potato for the economic benefit of the potato growers, while the use of potato fibres allows the food industry to efficiently increase the nutritional value of its products.

CIRCULAR ECONOMY IN THE PORK VALUE CHAIN



Optimising side streams

Danish Crown, one of the world's biggest pork producers, is cooperatively owned by Danish farmers who are both our suppliers and owners. Production and possibilities for optimising side streams is seen across the value chain from farm level to slaughterhouse. The value chain is no stronger than its weakest link, the result being today that Danish Crown represents one of the most efficient meat producers in the world.

The secret behind Danish Crown is the focus not only on producing meat, but also on producing and recycling other products such as sustainable energy, fuels, feed, nutrients and inputs for the pharmaceutical industry. Resource efficiency is a key part of the DNA. Investments in the value chain, such as breeding of animals, new

effective stables, feed optimisation, recycling of nutrients, as well as improving energy and water efficiency, logistics and utilisation of side-streams, are interconnected. They generate valuable knowledge-sharing through the value chain, ultimately benefiting the owners.

Based on this philosophy, Danish Crown demonstrates that they produce more with less, creating more value for the customers, suppliers, owners as well as society in general, the climate and environment. Circular economy principles are therefore nothing new to Danish Crown.

7. BUILDING CIRCULAR

Realising the enormous potential of a circular economy in the built environment.

Construction and demolition accounts for around 30 % of the waste generated in the EU⁸, and most of the value of building materials is lost after demolition. This presents enormous potential and opportunities for innovation.

The case for building circular is clear-cut. The market is growing and the savings that can be achieved are promising. The European market alone is estimated to amount to as much as EUR 440 billion for more sustainable building materials. The circular economy potential for the construction and real estate sector in Denmark has been estimated to amount to EUR 850-1200 million in 2035 based on three circular economy opportunities: industrialised production and 3D printing of building modules; reuse and high-value recycling of components and materials; sharing and multi-purposing of buildings.⁹

A number of Danish companies provide products to support circular building. In one demonstration project, "Building a Circular Future", a group of actors joined together in an innovative partnership to test a business case which revolved around reusing materials strategically. The total potential for the whole building, calculated in projected material prices, was estimated to be

up to 16% of the total construction cost¹⁰. Some of the main opportunities being addressed by Danish companies are summed up below;

- **Increased access to knowledge:** Through rapid digital development, building data, including their material content and details about their construction, are now registered in databases and IT programs for construction programmes.
- **Non-toxic buildings and materials:** A number of Danish companies now offer fully declared products as well as products with little or no problematic chemicals and toxic emissions. It was especially in the 1950s and 1960s, with the use of a number of new chemicals in construction, where we learned that a circular building sector depends both on quality and content of materials as well as their accessibility and knowledge about their use and location.

- **Design for disassembly and waste prevention:**

Businesses are developing business models, buildings and products which are flexible and allow for components and products to be recycled (e.g. by being dismantled and used for high-quality recycling).

- **Increased cooperation:**

Businesses are re-inventing the supply chain and business models - engaging actors across the sector to optimise the full cycle of a building and its components.

- **Upgrading waste materials for use in the building sector:**

The industry is using secondary raw materials from other sectors and the building sector itself at a higher use value than gravel for building roads, for example - such as biological materials from farming or concrete from buildings. This development is also apparent in the numbers of buildings with environmental certification like the Nordic Eco-label Svanemærket and DGNB.



The Danish regulatory framework and government initiatives have supported this development. In 2013 and 2015, the Government launched a waste management and a waste prevention strategy, respectively, highlighting the construction and demolition sector as an important area. Aiming to decrease waste deposits and incineration, the government is reshaping regulations to increase reuse and recycling, e.g. by prohibiting incineration of some materials, charging higher taxes for disposal, engaging in a dialogue on policies, procurements and acquisitions, and instead moving towards more sustainable and circular construction, including establishing a centre to increase knowledge and a grants programme for developing new technology for sustainable and circular construction.

⁸ http://ec.europa.eu/environment/waste/construction_demolition.htm

⁹ EMF 2015: Potential for Denmark as circular economy. A case study from: Delivering the circular economy - a toolkit for policy makers.

¹⁰ 2016 Building a Circular Future



Image: 3XN

Building a circular future

The construction industry accounts for one third of all the waste and CO₂ created, and more than a third of all the material used globally. 3XN Architects, along with its green think tank GXN, recently released a book, 'Building a Circular Future', which explores how the industry can implement circular building practices – an optimised approach construction where waste is turned into a positive business and where design for disassembly creates highly flexible buildings that are faster to construct and optimises operation and maintenance.

Parallel to the publishing of this book, 3XN implemented circular principles and strategies in the new Quay Quarter Tower in Sydney. The new landmark 200-metre skyscraper was constructed by

reusing and upcycling an existing tower on the site. It retained 60% of the structural skeleton and 98% percent of the structural walls. This saved significant time in construction and material resources, equating to significant cost savings that could be applied towards a new and better building for its users.

3XN Architects and GXN Innovation, MT Højgaard, Kingo Karlsen, VIA University College, Vugge til Vugge Danmark, Henrik Innovation and AMP Capital

For more information and the book available in open source, go to www.stateofgreen.com/en/profiles/3xn

Re-using old bricks to build a greener future

The driving force behind the founding of the company "Gamle Mursten" ("Old Bricks") was the desire to prevent resources of natural bricks from being wasted. Since its founding, "Gamle Mursten" has expanded greatly, and is now a large-scale cleantech production company with patented cleaning technology which ensures that building waste can be reused without the use of any chemicals. The old bricks are collected, cleaned with vibration technology, manually checked one by one and finally stacked by robots before being shipped to new sites. Saving more than

95% of the energy otherwise used to manufacture new bricks, this method of re-using old bricks is an example of perfect circular economy passing the resources of one generation on to a new one. By applying its method to two thousand bricks, "Gamle Mursten" also prevents the emission of one tonne of CO₂.

Realdania Byg and 3XN Architects used 300,000 old bricks making the Castle of Hindsø hotel (see picture), saving the environment of 150 tons CO₂.



Photo: Rebrick

8. UNLEASHING THE POTENTIAL OF CIRCULAR ECONOMY

The circular economy is here to stay - and Danish companies can help accelerate the transition.

The previous chapters have demonstrated the ways in which many Danish companies are leading the way by developing pioneering circular economy solutions for the benefit of the environment and their own competitiveness.

The circular economy model was born not only out of the necessity to change the course of today's linear model, but also out of the huge opportunities for both the environment and business in delivering new circular solutions.

The concept of a circular economy has managed to climb the stairs to the top floor of the international political agenda as well as the business agenda in a very short course of time. The concept unites the aspirations of delivering economic growth, job creation and protecting a global environment that is under pressure. However, the journey towards a circular economy has only just started.

This publication has shown how Danish companies across different sectors are leading the way in delivering circular economy solutions to a growing global market - with the potential to serve the global need for such solutions. The circular economy is certainly a market-driven agenda, yet unleashing the full potential of circular economy principles requires close collaboration between public and private actors to create holistic solutions and to overcome legislative barriers.

A transition to a circular economy is a paradigm shift that requires a change of mindset among, the financial sector, policy makers and companies. Cooperation

between different stakeholders will be key to a successful transformation.

We are only at the beginning of the journey towards unleashing the full potential of a circular economy. The future will provide new opportunities for innovations, use of digitisation, new models for reverse logistics and the shared economy.

Denmark as a circular economy solutions hub

Denmark has a long and rich track record of innovative policies aimed at stimulating the circular economy, a long-term strategic commitment to energy efficiency and renewable energy and a business community which pioneers green solutions. Already today, numerous Danish companies across a variety of sectors are leading the way in developing circular economy solutions.



DENMARK – THE STATE OF GREEN

In Denmark, more and more companies are becoming aware of the significant growth opportunities in the circular economy. Denmark has many leading companies pioneering circular economy solutions, a long and rich tradition of innovative policies aimed at stimulating the circular economy, as well as a long-term strategic commitment to energy efficiency and renewable energy.

Denmark - the State of Green

Since the 70s, Danish governments have addressed the issue of the country's limited natural resources, concentrating on using them wisely while pushing for energy efficiency measures. As a nation, we are known for our ability to collaborate, and our expertise is in helping customers and stakeholders reach highly efficient and 'smart' solutions, while in turn developing their ability to profit from that knowledge. We see great opportunities for mutual benefits in the transfer of knowledge, spurring

growth in both partners' businesses - holistically, with a great deal of respect for different perspectives, agendas and the environment.

Explore, learn and connect online

State of Green gathers all the leading players within the circular economy in Denmark. Stateofgreen.com is the official platform for Denmark's green solutions and knowhow. The web portal is an online entry point for all relevant information about Danish companies and institutions and their expertise within Denmark's ten green strongholds.

Come visit us in House of Green

House of Green is an interactive visitors' and exhibition centre located in the heart of Copenhagen. House of Green uses a combination of guided storytelling and self-exploration to showcase green Danish integrated solutions and scenarios, as well as an overview of the overarching Danish

story within energy, climate, water and resources. Danish representatives act as hosts that both inspire and inform delegations before they move on to on-site visits. For more information about House of Green, please visit houseofgreen/stateofgreen.com.

Experience implemented green solutions - live!

A cornerstone of the Danish vision is to inspire others and demonstrate how a green society is both possible and profitable - and we invite people to come see for themselves. Through our State of Green Tours, we offer commercial and political decision-makers and journalists from around the world a chance to take advantage of the lessons learned by leading Danish companies and institutions within the different fields of the circular economy, and to see Danish green solutions - live. For more information about State of Green Tours, please visit stateofgreen.com/tours

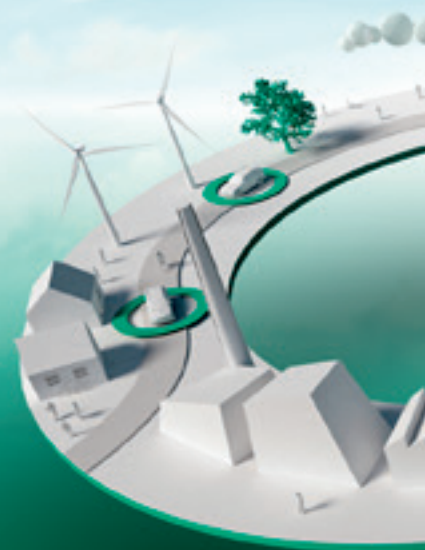


About State of Green

State of Green is a public-private partnership founded by the Danish Government, the Confederation of Danish Industry, the Danish Energy Association, the Danish Agriculture & Food Council and the Danish Wind Industry Association. H.R.H. Crown Prince Frederik of Denmark is patron of State of Green. As the official green brand for Denmark, State of Green gathers all leading players in the fields of energy, climate, water, and environment and fosters relations with international stakeholders interested in learning from the Danish experience. Visit www.stateofgreen.com to learn more.

Learn more about Danish circular solutions, find more cases from around the world and connect with Danish experts at:

www.stateofgreen.com/circular-economy/



State of Green is a non-profit, public-private partnership founded by:

