

WHITE PAPERS FOR A GREEN TRANSITION

The business of a circular future

How business models can accelerate the transition to a circular economy

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Circularity from use of data, digital tools, and design

More value from waste



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BUSINESS MODELS FOR A CIRCULAR TRANSITION

How business models can accelerate the transition to a circular economy

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Unsplash

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Executive summary

Globally, more natural resources are consumed than what is sustainable for our finite planet. According to the United Nations, the extraction and processing of natural resources is responsible for around half of all global CO₂ emissions and over 90 per cent of global biodiversity loss. It is evident that we have a shared challenge in decoupling growth in resource use from population and income growth. A transition to a circular economy will enable this.

Accelerating the transition

A widespread adoption of circular business models can accelerate the transition to a circular economy. By addressing product life extension and reuse as well as the recycling of waste, circular business models can reduce resource consumption and minimise waste generation. They allow products to be continuously used, reused, sold as a service, and enable the sharing of underutilised and idle products, rather than incentivising a one-time purchase. Another essential part of accelerating the transition is the invention and production of new materials through circular bio-based business models. A commonality and driving forces are data collection, digital tools and design of these, ensuring access as well as assuring quality in reuse and recycling.

Going circular with partnerships and collaboration

Public and private collaboration is crucial in converting challenges into opportunities at a national, regional and global level. More and more Danish businesses are adopting circular business models, because it has proven to be a sound business strategy that facilitates access to new markets, drives innovative solutions and lowers production costs. Throughout this white paper, specific company examples will be used to exemplify and demonstrate how new innovative business models can benefit the environment, the climate and the economy.

Find more inspiration for your circular and sustainable future

Hopefully this white paper will inspire others to accelerate the transition to a circular economy. It features lessons learnt from different Danish stakeholders within circular business models. It is meant to serve as an inspirational tool for creating innovative circular solutions that contribute to a smarter and more sustainable use of our globally shared resources.

More white papers on greener and more sustainable futures are available at www.stateofgreen.com/publications

Ministers' foreword

"WE ARE MAKING AN IMPORTANT PARADIGM SHIFT FROM A TAKE-MAKE-WASTE ECONOMY TO A CIRCULAR ECONOMY. WORKING TOGETHER IN PARTNERSHIP WITH BUSINESSES AND INDUSTRY, WE WILL MAKE THE TRANSITION TO A CIRCULAR ECONOMY POSSIBLE BY RETHINKING OUR WAY OF PRODUCTION AND CONSUMPTION, CREATING NEW BUSINESSES, NEW JOBS AND A MORE SUSTAINABLE WAY OF LIVING."

As the world's population grows, and our collective consumption of resources increases, we must move towards less material intensive lifestyles. In Denmark, we have chosen to approach the transition to a circular economy through collaboration, education, and knowledge sharing.

The Danish government, together with a broad majority in the Danish Parliament, has set a goal of reducing greenhouse gas emissions. We want to reduce emissions by 70 percent in 2030 compared with 1990 level. It is an ambitious goal that requires new instruments and solutions. All sectors have to contribute – energy, transport, agriculture, manufacturing, water, waste and services. And it means, that we must work together – across the private and public sector, universities and the civil society.

Denmark has a strong tradition for cooperation between the public and the private sector – as well as cross-sectoral partnerships. And such cooperation is key in finding the needed innovative solutions for a circular transition. Our national strategy for a Circular Economy has been established on the basis of cooperation between both public and private stakeholders, where the focus is set on creating more value from materials and less waste through circular innovation and design, production, reuse, remanufacturing and recycling.

Therefore, circular economy in Denmark is a matter of rethinking business and business-as-usual by supporting concrete and actionable circular business models and solutions essential to the transition. The stage is set for Denmark and Danish businesses to use circular economy opportunities as a growth engine driving the green transition. In Denmark, we must produce less waste and recycle much more with a higher value than we do now.

With an ambitious climate goal, a national strategy for a circular economy and a broad cooperation between state, industry sectors, and civil society we are moving towards the uptake of new solutions for a more sustainable future. Moving to a circular economy is a challenge we must meet and a way to fulfill the 17 UN Sustainable Development Goals.

This White Paper illustrates the policy frameworks underpinning Denmark's transition to a circular economy. It provides insights into key elements supported by best-case examples and outlines the path to a greener future through the development and adaptation of circular business models.

We hope the solutions contained in this white paper will serve as an inspiration to you.



Simon Kollerup
Minister for Industry, Business and
Financial Affairs, Denmark



Lea Wermelin
Minister for the Environment, Denmark

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CHAPTER 1

Circular Economy – solutions to global challenges

Globally, more natural resources are being consumed than what is sustainable for the finite resources of the planet.

According to the UN, the extraction and processing of natural resources is responsible for approximately 50 per cent of global CO₂ emissions and over 90 per cent of the global biodiversity losses. There is a shared challenge in decoupling the growth in resource use from continued population and income growth. A transition to a circular economy would enable such a decoupling.

Valuing resources in Denmark

In Denmark, the use of resources in a sustainable, efficient, and responsible manner has been at the centre of Danish regulations and business models for decades. This is evident in the country's historic development since the 1980s, where national energy and water consumption has been decreasing, while economic growth has simultaneously increased. Similar decoupling is to be obtained across all sectors, as the country transitions to a circular economy.

Sustainably reaching development goals

A transition to a circular economy encompasses substantial potential, not only for the environment, but also for economic competitiveness. By using less resources, reusing materials, and increasing the recycling rate of materials, businesses can increase their resource productivity and thereby create more value from the same amount of resources. It is a central and necessary step towards achieving the 17 UN Sustainable Development Goals. The transition to a circular economy contributes to the development goals in a number of ways – both directly and indirectly, and particularly manifests its relevance through SDG12, Responsible Consumption and Production.

What is Circular Economy

Looking beyond the current take-make-waste extractive industrial model, a circular economy aims to redefine growth, focusing on positive, society-wide benefits. It entails gradually decoupling economic activity from the consumption of finite resources and designing waste out of the system. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural, and social capital. It is based on three principles:

- Design out waste and pollution
- Keep products and materials in use
- Regenerate natural systems

(Source: <https://www.ellenmacarthurfoundation.org/circular-economy/concept>)

Accelerating the transition through circular business models

The widespread adoption of circular business models can accelerate the transition to a circular economy, as they serve to reduce resource consumption and waste generation. Policymakers and regulators have a role to play in facilitating the adoption of circular business models. In turn, businesses and industries that adopt circular business models can support the transition by achieving efficiency gains through higher resource and economic productivity, reductions in CO₂ emissions, and new opportunities for jobs and prosperity. Five examples of circular business models are described below:



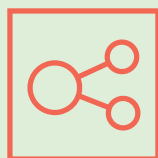
Product life extension and reuse: maximising utilisation rates, achieving optimal value out of the energy and resources used to produce a given product with durable and easily repaired products.



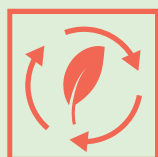
Recycling of waste: ensuring that when the lifetime of products can no longer be prolonged, materials of the product can be kept in circulation and used in the production of new products through recycling.



Product-as-a-service: enabling access to – rather than owning – a product or asset through leasing, renting or pay-per-use plans. Repair and maintenance-schemes are often included, without immediate costs for the consumer.



Sharing business models: the same products are made available to more than one user. It facilitates the sharing of products that are otherwise underutilised between consumers or companies.



Circular bio-based business models – materials extracted from virgin resources are replaced with bio-based, renewable, or recovered materials. By-products from production processes can be upgraded to obtain high-value products and energy as well as optimising resource efficiency throughout the production process.

In many cases, realising these circular business models will require the use of data collection, digital tools, and design. Strengthening reporting practices and data collection is particularly significant, as information about product design and material content, quality and origin are necessary inputs to evaluate whether a product can be better designed, repaired, reused, recycled, or needs to be maintained.

Towards a sustainable future in Denmark

Policies and partnerships enabling future visions and innovations.

Working to a future-oriented agenda, Denmark is aiming to become an ever cleaner, and more competitive nation via a circular and climate-neutral economy. A number of European and Danish goals and visions have been set that outline the direction for this transition. Denmark has a goal of reducing its greenhouse gas emissions by 70 per cent by 2030 (with 1990 as the baseline year) and aims to achieve a climate-neutral waste sector by 2030. Total climate neutrality is targeted for 2050, while recycling targets aim to ensure 60 per cent of Danish household waste and 70 per cent of packaging waste are recycled by 2030.

Key public-private partnerships

Transitioning to a circular economy requires collaboration, education, and knowledge sharing amongst policymakers, business leaders and universities. Doing so creates innovative solutions which are then refined, and implemented for mutual benefit, and without job losses or lowered efficiency or living standards. Addressing essential value chains

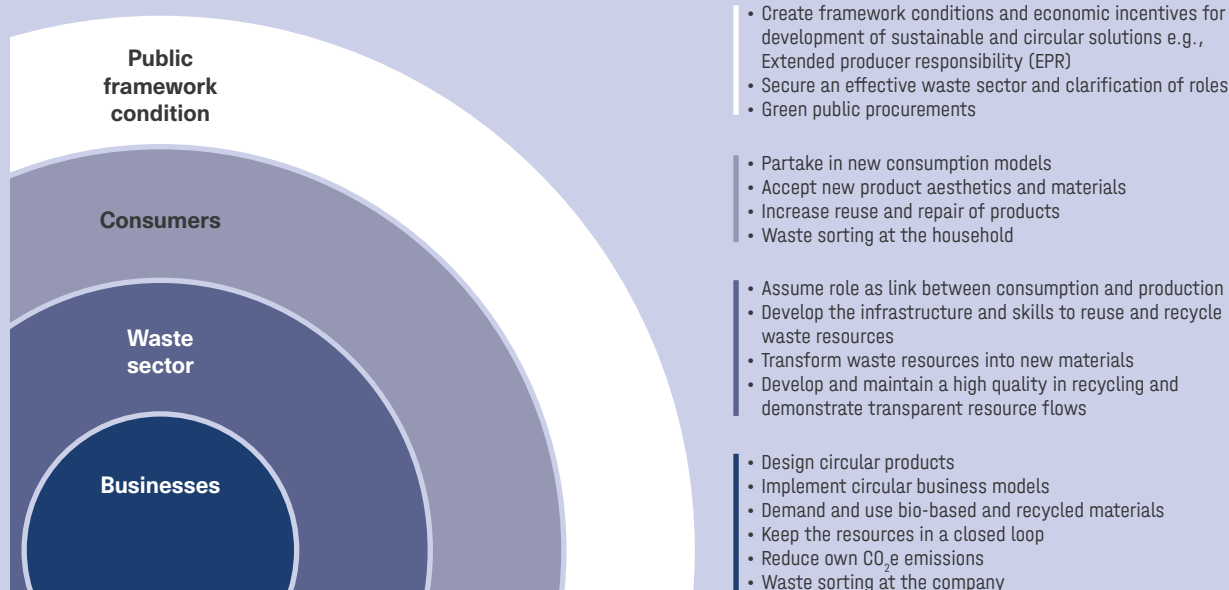
is often a matter of great complexity. Dialogue between authorities and the commercial sector in order to overcome barriers is of great value for both parties. At times, current regulations may pose obstacles to value chain development. Therefore, appropriate regulatory framework conditions for circular economic development are important to drive dynamic development and ensure a reliable supply chain.

Denmark has a strong tradition for collaboration and partnerships between the public and the private sector, as well as cross-sectoral partnerships. In collaboration with the private sector in 2019, the Danish government established 13 climate partnerships. The partnerships were created to strengthen public and private sector collaboration in order to realise climate objectives by 2030. The partnerships span across all sectors and industries. The climate partnership on waste, water and circular economy presented recommendations regarding how Denmark could become a world leading circular economy by 2030, highlighting measures to

Climate benefits

The climate partnership for waste, water and circular economy estimates an overall global CO₂ emissions reduction of approximately 7 to 9 million tonnes by 2030 and approximately 12-16 million tonnes by 2050 from the transition to a circular economy in Denmark. In comparison, Denmark's consumption-based climate footprint is estimated at 61 million tonnes of CO₂. The CO₂ emissions reductions that will arise from the transition to a circular economy are primarily created by longer product lifetimes, reuse, higher value in recycling, less need for extraction and the production of new materials, fewer emissions from waste incineration and changes in consumption patterns. The use of recycled materials in the production of new products, is the area with the greatest potential for CO₂ emissions reductions.

Circular transition demands collaboration, partnerships, and increased coupling across sectors



be taken both politically and within industry. Several of the partnership's recommendations on waste, have now been adopted into the latest political agreement on the area.

Collaborative participation for circular success

An ambitious economic transition of this scale requires participation from all levels of society.

- The public sector must create the right framework conditions and financial incentives for the development and scaling of circular solutions. Similarly, the public sector through public procurement can strategically promote the demand for circular solutions and thus create the necessary scale.
- The waste sector will need to become the pivotal link between consumption and production, possessing the infrastructure and skills to reuse and recycle waste resources. This denotes the ability to transform waste resources into new materials, develop and maintain a high quality in recycling and demonstrate transparent resource flows in order to enable a favourable market for those resources.
- Production businesses need to design products with a focus on increased circularity, develop new business models and demand bio-based and recycled materials.
- The customers of those products need to adapt consumption patterns to include and choose products as well as services that are part of the circular economy and prevent waste. This also includes accepting new types of materials, business models and sorting waste into different fractions to best enable the waste sector in fulfilling their role, entering resources into circular rotation.

Research, development and innovation funding

Innovation and research are a key drivers in the future development of circular economy business models. The Danish Government promotes the development and use of new technologies and modes of production from research stages through demonstration and pilot experiments, to full-scale commercial plants as well as the transition to new circular business models. Important initiatives driving the green transition are the Danish Development and Demonstration Programmes (GUDP, MUPD, EUDP). These are grant programmes, which promote sustainability and growth in collaboration between industry and research within food, energy and environment. Other important measures include; the co-financing programmes targeted SMEs to implement new circular business models, initiated by the Danish Board of Business Development. Also, a new green research strategy is financially supported by the government focusing on e.g. strengthening international and public-private partnerships within different missions – one of them being circular economy.

Business opportunities in reuse and extended product life

Prolonging product life through design and reuse is an effective way to retain value, prevent waste and reduce CO₂-emissions.

Prolonging product life through better design and smarter consumption is an effective way to retain value, prevent waste and reduce CO₂ emissions. With appropriate design, businesses can manufacture products to achieve optimal duration of use and resell potential, adding to revenue and market competitiveness. Expanded revenue opportunities exist when a business sells a new product with the option to return it after end use. The business can repair and resell the product, leveraging the production efforts initially used, potentially doubling revenues. A revenue model can also be created based entirely on reuse, where the business buys preowned products, then repairs, upgrades and resells them.

Reuse in Denmark

The market for reuse is growing across Europe, and Denmark is no exception. In Denmark, the market for reuse consists of an expanding number of actors and takes place as e.g., exchange, loan, sale of reused products at flea markets, libraries, websites, auctions and through businesses. It is both private and charitable organisations, municipal actors and consumers-to-consumers that are involved in the pre-

vention of waste and the promotion of reuse. Social media and digital platforms are actively used for sales and the exchange of second-hand products. According to a survey conducted by one of Denmark's web-based reuse platforms, almost 80 per cent of the population bought or sold used products in 2019.

Beside the public interest in reuse, there is also an increased interest in reuse between companies. More and more companies specialise in receiving, buying, and selling pre-owned products, such as office furniture, clothes, building materials, bikes, and electronics such as phones, tables etc. Others establish take-back schemes, where customers can return i.e., used clothes. Business models based on products-as-a-service, or the sharing economy is also increasing the reuse of products.

Preventing waste

In Denmark and the EU, the proliferation of reuse and product life extension schemes are part of an ongoing effort to prevent waste. Some examples on how to prevent waste and promote reuse are:



Producer responsibility

Extended producer responsibility (EPR) is mandatory for electronics, cars and batteries in Denmark and rest of the EU. From 2025, EPR for packaging will also be mandatory. An extended producer responsibility system stipulates that businesses have the obligation to pay for the collection, reuse or recycling of their marketed products. With the inherent financial burden of this obligation, companies have a clear incentive to design products for reuse and recycling. By ensuring reuse of their products, producers can delay the products' entry into the waste stream, realising savings as well as the possibility of generating revenue from the resell on the behalf of the individual businesses.

Green public procurement

Green public procurement can promote a market for circular solutions. Demanding products with environmental labels, repairable products, reused products, or take-back-schemes, promote a market for products with a longer product lifespan. Using Total Cost of Ownership principles when evaluating tenders is another method to promote circular solutions. Total product lifetime costs are considered

and taking into account the longer perspective of quality and reparability, costs tend to be lower than the comparable conventional product.

Trust in reuse with quality standard assurances

Today, reused materials are often traded without with the same guarantee as new products, potentially leading to costs later on if the material does not last. Further increases in the supply of reused products require clear rules and new ways to document the quality and performance of reused products. Establishing quality standards for preowned products is one way to overcome some of these barriers. This entails standardised ways to document content and properties of products' quality, durability etc. Standards and certifications are essential to create assurance that the reused materials do not pose a health and environmental risk or impair the quality of the products. It is a means to create trust for customers in the market for reuse.

Reusing materials for The Resource Rows

The construction industry in Denmark accounts for approximately 30 per cent of the country's total CO₂ emissions and one third of the country's waste generation. The Resource Rows, a housing project consisting of 92 flats, demonstrate a radical reuse approach to materials that significantly reduces the construction carbon footprint.

The flats are arranged around a shared courtyard and roofscape with 29 greenhouses made from reused wood and windows. The walls are built using upcycled bricks taken from a demolished Carlsberg brewery. As the brewery bricks were cement mortared and difficult to disassemble, Lendager developed a method whereby large squares would be cut from the old facades. Brick modules in different colours were then assembled in new designs, giving the building a patchwork like facade. All internal floors were made of waste wood from the flooring manufacturer Dinesen, which would otherwise have been burned.

When building the Resource Rows, 10 per cent of the materials are upcycled waste materials, while the overall CO₂ reduction is 29 per cent compared to benchmark reductions. Around 300 tonnes of wood waste were sourced from construction of the city's new metro and used externally for terraces etc. Each reused brick represents a CO₂ saving of 500g and the wood a CO₂ saving of 77 per cent.



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Lendager
NREP

LOCATION

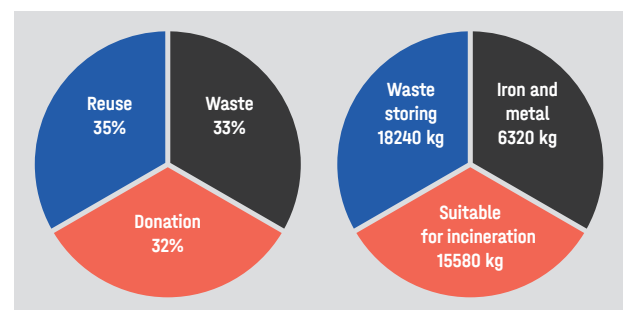
Copenhagen, Denmark

Extending the life of office furniture

A challenge of the furniture industry is the amount of preowned furniture going to waste. In the EU alone, an estimated 10 million tonnes of furniture waste is generated annually and approximately 10 per cent is reused. To alleviate this, the Danish furniture producer, Holmeris B8, and provider for offices, hospitality, learning and care institutions, created a 'take-back system'.

In connection with a domicile move by biotechnology company Novozymes, the preowned office furniture was repurchased and prepared for reuse. Approximately 35 per cent of the furniture was resold, optimising the initial use of resources spent producing the furniture. The surplus furniture, with continued use value, but no real resale value, have been matched and donated to five schools, a sport association, kindergarten, and a senior citizens centre. The remaining 33 per cent was disassembled and disposed of sustainably.

For Novozymes, the 'take-back system' offered a sustainable footprint to their move. For the circular furniture company, it offers resell value for some of the furniture and savings on disposal charges on furniture restored and donated for prolonged use. The learning and care institutions, now have applicable furniture to use e.g., whiteboards in the schools and conference chairs for gatherings at the senior centre.



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HOLMRIS B8
Novozymes

LOCATION

Bagsværd, Denmark



Reducing e-waste and CO₂ emissions

Globally, more than 100 million computers are produced annually, many of them with life cycles of only a few years. Adding to this is the estimation that 80 per cent of the energy a computer uses throughout its lifetime is used for its initial production, meaning that short-lived computers, and other electronics pose great challenges once they become someone's waste.

Extending the lifetime, delaying the undesirability of electronics and recycling what is no longer reusable, has become the main challenge to solve for Tier1Asset (T1A), who purchase used computers from companies worldwide. The refurbishing process of the electronics include an ISO certified product handling, secured data erasure and installation of the operating system, quality check and product classification. Of all IT equipment purchased, 90 per cent is upcycled and sold for reuse, while the remainder is recycled. The Danish refurbishing company has partnered with Stena Recycling, where the remaining 10 per cent is recycled and the materials, such as gold, are recovered for other manufacturing purposes.

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Lillerød, Denmark

More value from waste

Closing the circular loop between production and consumption, gaining more value from waste through recycling.

When the lifetime of products can no longer be prolonged, its materials can still be kept in circulation. Through recycling, those materials can be used in new products via the integration of materials derived from waste.

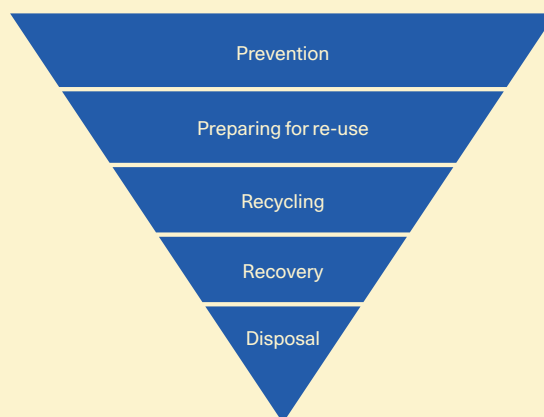
Increasing recycling and ensuring material recycling of a quality so that it can be used in new, high-quality products is not without its challenges. The design of products determines how easy it will be to recycle the products. Contents containing hazardous substances, whether the material of the product can be separated and how many different types of material the product consists of are examples of elements that can affect the recycling potential. This makes collaboration between the waste collection and treatment industry and producers of new products essential.

Waste management for material circulation

Each year, the Danish waste sector collects and processes almost 13 million tonnes of waste. Of this, almost 50 per cent is directly recycled and 24 per cent is recovered and used as replacement materials. Danish waste-to-energy plants convert 25 per cent of the total waste into heat and electricity production and are some of the cleanest and most efficient in the world. In addition to being a low-carbon energy source compared to oil, gas and coal, the use of landfills has, partly due to waste-to-energy practices, been reduced by 40 per cent from 1980 to today, where less than 4 per cent of waste

is landfilled. This was the result of developing clear targets in waste management planning, spanning from the national to the local level.

The waste hierarchy positions waste prevention as the most preferred option, followed by reuse, then recycling (including composting). The least preferable options are energy recovery (incinerating waste to produce electricity and/or heat) and landfilling.



The waste hierarchy is commonly used to prioritise waste legislation, goals, and initiatives in the EU as well as in national and local waste plans. (Source: European Commission)

For decades, metals, paper, cardboard, wood and glass has been recycled into new materials in Denmark. With the increasing focus on the circular economy in Denmark and the EU, Danish businesses in the waste sector have developed new ways to recycle concrete, plastics, oil, batteries, etc. New collaborations both upstream and downstream provide possibilities for recyclers to give input to the designers and ensure that products are recyclable and where possible, can be used in closed loops.

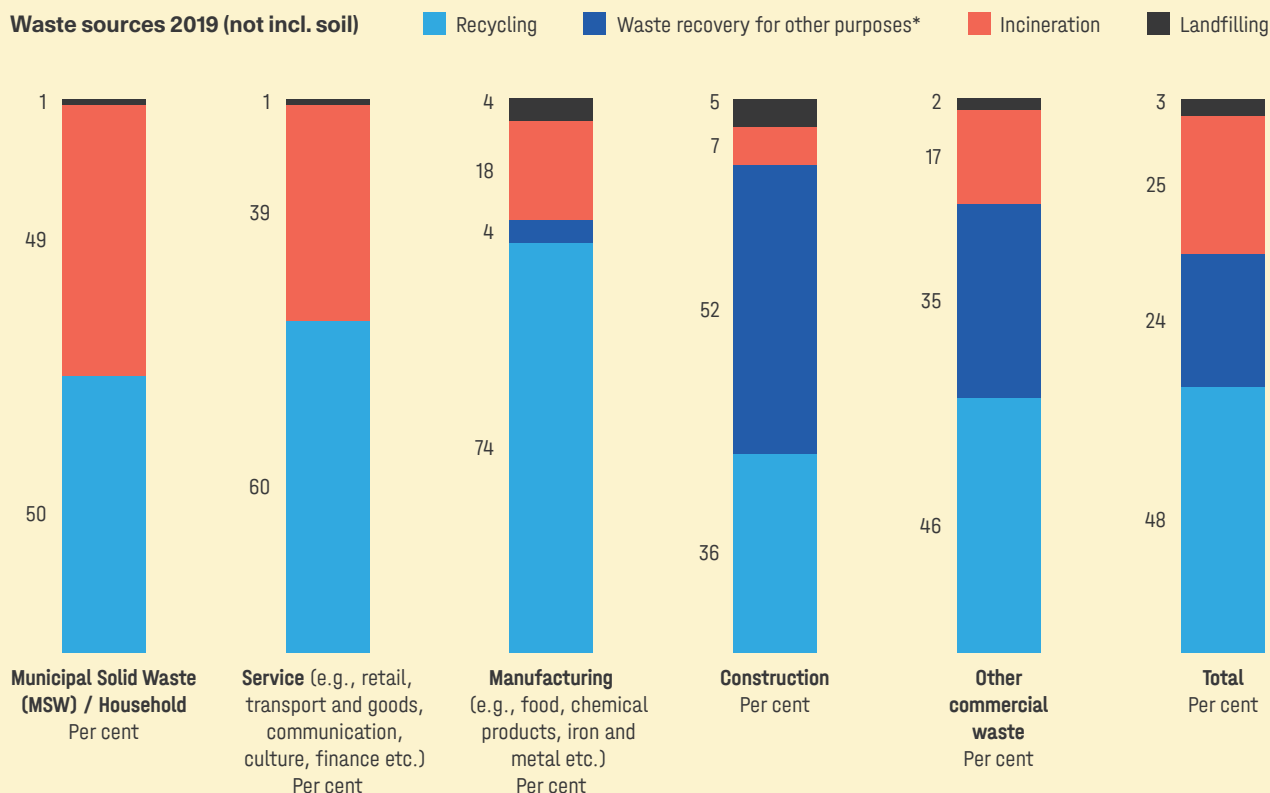
Industrial scale Danish recycling sector

Efficient and high-quality recycling requires uniform waste sorting to ensure large, homogeneous waste streams and the establishment of sorting and recycling facilities. In a circular economy, the recycled material from waste has to meet the raw material requirements asked for by producers, and it has to compete with virgin materials in terms of quality, price, and security of supply. That requires waste recycling at an industrial scale, essentially escalating the industry, with new jobs to close the loop between production and consumption and keep materials in circulation.

In 2010, Denmark transferred responsibility for commercial waste away from the municipalities and on to the open market. All businesses became obligated to use a registered waste company for the collection of their waste. This has expanded the market and essentially created a new industry of private waste businesses and ensured a steady incline in the recycling of commercial waste.

Aiming for similar conditions for the recycling of household waste, a new national scheme is being implemented in 2021-22, which includes kerbside collection of 10 different types of waste (paper, cardboard, plastic, metal, organic, glass, textile, dangerous waste, other residual waste, and food cartons) from households and smaller businesses. After collection of the waste fractions, the municipalities need to tender sorting and recycling of the waste on to the market. This uniform way to sort and collect waste means larger and more homogeneous waste volumes, ensures a more efficient waste system and makes new investments in recycling facilities and technologies more profitable. The vision is to build a large recycling sector in Denmark and for the circular economy to become the next green export adventure.

Waste sources 2019 (not incl. soil)



Status of Danish recycling in 2019. In general, commercial waste recycling is performing better than MSW.

*Waste used to replace other materials for e.g., filling purposes, but is not prepared for reuse or recycled.

(Source: Danish Environmental Protection Agency Waste Statistics 2019 December 2020)



CO₂ emissions reducing tire recycling

Each year, more than 20 million tonnes of tyres are discarded worldwide. If disposed of at landfill sites, these end-of-life tyres are left to pollute the environment, and if incinerated for energy recovery, large amounts of CO₂ and potentially toxic fumes as well will be released.

Tyre recycling company Genan has turned this immense waste problem into a green opportunity – and can process and recycle up to 150,000 tyres daily worldwide. Tyres are shredded, granulated and separated into valuable secondary raw materials: rubber granulate and powder, steel and textile; and these products can be used for numerous sustainable applications, substituting virgin raw material.

The recycling of tyre steel limits the need for iron ore mining, and the recycling of tyre rubber limits the deforestation of rainforests for rubber plantations. Additionally, each tonne of tyres recycled at Genan equals 0.7-1.1 tonnes of CO₂ emission savings when compared to incineration, which is the alternative disposal method.

Rubberised asphalt is one climate conscious application that recycled ELT granules can be used for, and it is also a cost-efficient solution, as rubber-modified asphalt is less exposed to rutting and cracking, requiring less maintenance. Research furthermore confirms that rubber-modified asphalt reduces traffic noise and provides a better road grip in wet weather. Moreover, far fewer tyre and road wear particles are released than is the case with traditional asphalt.

CONTRIBUTORS

Genan

LOCATION

Houston, Texas
Viborg, Denmark



Changing plastic household waste to high quality recycled granulate

In Denmark alone, approximately 350,000 tonnes of plastic waste is generated annually, where household plastic waste is estimated to comprise approximately 120,000 tonnes of this figure. A challenge in recycling this has been that the collected plastic waste generally consists of both recyclable plastic and unrecyclable plastic with e.g., remnants of previous content food or other.

To meet this challenge, Scandinavia's largest company within plastic regeneration, Aage Vestergaard Larsen, has created a machine and a process, where collected plastic, both recyclable and soiled, is cut into small pieces and conveyed into the machine that rinses and separates the plastic through density sorting. One type of plastic recycled here is polyethylene (PE), the most widely used type of plastic that has its primary use in packaging. Another is polypropylene (PP) that has a high chemical resistance, primarily used in medico and clothing industry. The rinse and separation of the plastic fractions makes the high quality regrind readily usable for new plastic-based products.

A full production line will be completed in 2021 with a capacity to receive 4,000 tonnes/year of PP and PE, from pre-sorting facilities across Europe. It is estimated that the 4,000-tonne capacity will save the environment from 9,600 tonnes of CO₂, compared to using virgin plastic.

CONTRIBUTORS

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Mariager, Denmark



Industrial production of recycled concrete aggregate

The production of concrete requires a significant amount of scarce virgin resources and is a process with a large carbon footprint due to the use of cement. Whilst concrete waste in Denmark accounts for more than 25 per cent of construction and demolition waste annually, recycling of aggregates from concrete waste has, at project scale, been proven to be technically feasible. To address this climate and resource challenge, recycling of aggregates from concrete waste must be elevated to industrial scale production, while adhering to high-quality standards.

The Danish EPA, RGS Nordic and Danish Technological Institute and a concrete manufacturer have established an industrial process for concrete recycling, including acceptance and classification of the concrete source according to technical specifications and hazardous substances status. The aggregate is crushed, sorted and washed to comply with EU standards. The process is fully traceable, from the origin of the concrete to its final use in new construction.

As characteristics of the recycled aggregates deviate from virgin aggregates, a new mixture guide was developed, consequently leading to concrete properties differing from virgin aggregate concrete. To ensure quality, the technical challenges addressed were the presence of impurities from other materials as e.g., wood and plastic and the uneven size distribution of the aggregates.

The outcome of the innovation project is a completely new product, recycled concrete aggregates, with higher resource and economic value as well as a reduced carbon footprint. The recycling of concrete secures use of high-quality concrete waste and reduces consumption of virgin materials.

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LOCATION

Copenhagen, Denmark



Recycling 100 per cent PET in packaging

Material choice is an essential lever to reach circularity in food packaging. Designing products made with materials that are not circular to begin with will never be a part of the circular economy. Mono-material PET packaging is currently the only plastic that can be circularly recycled into new food packaging, without compromising food safety or any other functional property.

Evolve by Faerch is a circular recycling and packaging concept, as it is made from up to a 100 per cent recycled PET. The products will have naturally fluctuating tones, as the packaging concept reflects the specific blend of recycled content that it is made from, hence a direct mirror of the European PET recycling stream. This also guarantees that the pots, tubs and trays are reliably detectable using today's sorting systems, as they have been detected before.

As a European society, the collective aim is to preserve the energy used in the raw material production and keep the material value in circulation, while phasing out the need for virgin plastics and incineration of valuable materials. As a result of an extensive innovation program at Faerch's recycling facility, output capacity will reach the equivalent of 1.2 billion recycled trays annually by the end of 2021. This allows the PET materials to stay in circulation, with a continued high standard for recycling. This is estimated to reduce CO₂ emissions by 60 per cent, when compared to using PET trays of virgin materials.

CONTRIBUTORS

Faerch

LOCATION

Holstebro, Denmark
Duiven, Netherlands

Circularity from leasing, renting, and sharing

Better and longer use of products can be achieved through changing from owning products to having access to products through leasing, renting and sharing.

Product as a service (PaaS) is a circular business model, where a company markets and sells the service of the product, instead of selling the ownership of the product. This can be done for example, by subscription or leasing schemes of products or physical facilities to the end user. Not too dissimilar is the sharing business model, which allows products to be available to more than one user. This business model differs from product as a service, in that it promotes sharing between multiple users. When several users share the same assets, the need for production of additional assets decreases, which in turn reduces the need to extract and produce new resources. At the same time, value is created for both the owner and the user.

Circularity aspect of Product as a Service

When producers retain the ownership of products and deliver the products as a service, it strengthens their incentive to produce products that remain more efficient throughout their life cycle and last longer by being easier to

repair, remanufacture and upgrade. In a product as a service business model, the producer maintains a close relationship with the customers and enables continuous cash flow for the company. A few practical examples that can be found in Denmark include:

- producers that deliver robots as a service by renting out modular robots, which can be easily repaired, upgraded, and reused by new customers. Leasing a robot is of great value for the customers, as it protects them from technical developments that, in a short time, can make the robotic technology outdated compared to the newly available technology, resulting in a loss of value.
- another example of product as a service model is the renting of anything from clothing to repair tools, cars, and the like. The same kind of business models can apply to buildings or other facilities delivered as a service.



Sharing business models

Sharing business models facilitate the sharing of products or assets that are underutilised. It can be assets belonging to companies or consumers that are in surplus, or assets that are idle and not in use. Often, the sharing of assets takes place via online platforms that match providers and users and provide information regarding accessibility and the location of the assets, e.g., unused cars or idle seats on car journeys. A car sharing business model can ensure a higher degree of utilisation of the car's capacity and reduces the number of cars that drive the same journey. The sharing economy is usually associated with asset sharing either from company to customer or from customer to customer. Businesses, however, can also gain value by sharing assets, machinery, excess facilities e.g., buildings with other companies. It can be digital marketplaces for the rental of machines, high tech equipment, special tools etc.

Driving a citizen ownership change

In Denmark, the tradition of collaborative ownership initiated by the cooperative movement within e.g., farming, housing or cooperatives serves as a strong foundation for future business models based on leasing, renting, and sharing. However, in a welfare society such as Denmark's, where high income per capita affords citizens ownership over a plethora of possessions, the driver for implementing an ownership change in a society like Denmark, can be found in changing consumer behaviour. The convenience of sharing or not owning a product, should outweigh the convenience of owning or not sharing the product. The PaaS-model offers convenience of access to functioning products, without the inconvenience of being responsible for the repair and upkeep. The sharing economy enables extra income for the owner of an un-utilised product and ease of access for a user to a non-owned product.

Sharing circular transport solution

Cars are one of the most underutilised resources in modern life. In Denmark, an average car transports 1.3 people on the road and spends more than 23 hours per day taking up parking space. Poor usage of cars is the largest excess capacity in the transport industry and this inefficiency has a negative impact on the environment, whilst also being expensive for car owners.

The digital sharing platform founded by GoMore enables people to share their cars or a seat on a planned trip through private car rental, shareable leasing, and ridesharing. The digital sharing platform now has 2.7 million members across Denmark, Sweden, Finland and Spain, leading the way for private car sharing

Enabling private car sharing minimises the expenses associated with car ownership and the negative impact on the environment. In 2020, around 33,000 unique Danish users rented a car on GoMore, totalling 65,000 rentals. As of May 1st, this year, the number of rentals in 2021 exceeds the 2020 figure by around 55 per cent. Since the platform was established in 2005, more than 2.3 million ride shares have been sold in Denmark alone. Keyless sharing technology makes it possible to book, lock and unlock private cars from the app and a keyless car is, in Denmark, on average shared between 12 households each quarter.



CONTRIBUTORS

GoMore

LOCATION

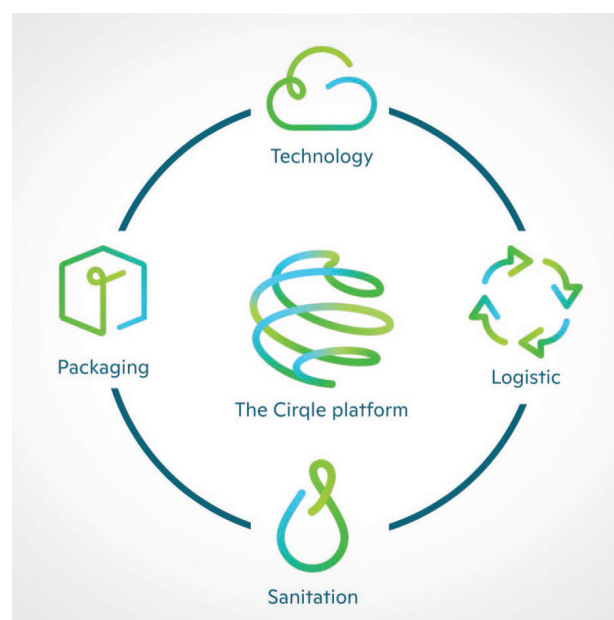
Madrid, Spain
Copenhagen, Denmark
Stockholm, Sweden
Helsinki, Finland

Closed loop in reuse packaging-as-service

Today's requirements for sustainability in packaging are increasing at every step of the value chain and consumers are increasingly looking for new ways to reduce packaging usage and waste. One way to do so is to offer circular models of reuse for food packaging.

Plus Pack, one of Europe's leading players in designing and producing circular packaging solutions to the food industry, and start-up Cirqle, which delivers reuse packaging-as-a-service, have introduced a new partnership to develop a reuse model for the primary packaging of foods. The solution also has the potential for convenience foods and take-away. The key elements in the partnership are close collaboration, standards, and scale. Cirqle develops a unique system and digital solutions to handle packaging in a closed loop, and four areas are in focus to offer reuse packaging-as-a-service; the design and production of food packaging which can be reused; a technology that enables the ability to track the packaging throughout its use; a system to transport the packaging between the different actors in the loop and not least ensuring food safety, quality and hygiene throughout all steps.

The reuse packaging-as-service offers a new circular consumption model, which reduces packaging and waste, thus encompassing the potential to reduce Co2 emissions by up to 60 per cent when compared to single use packaging.



CONTRIBUTORS

Plus Pack
Cirqle

LOCATION

Copenhagen, Denmark



Delivering energy efficient heating as a service

A public school in Denmark needed to expand and rather than endure large upfront investments for a new heating system, the school decided to subscribe to an energy efficient heating system delivered from Best Green. Offering heating as a product-as-a-service, the company purchases, installs and operates state-of-the-art heat pump systems and takes care of any ongoing maintenance. Heating pumps are energy efficient in that they use heat from the building's surroundings, such as the air or soil, and transfers that heat into the building's heating system e.g., radiators or floor heating.

The school of Hylke is now paying only for the energy they consume and a monthly subscription fee, whereas any services or unforeseen repair requirements are handled by the Danish heating company. To ensure high reliability of supply, the system is digitally monitored, enabling the school a guaranteed fixed monthly fee per KWh heating. Taking care of all the practical aspects of the service and maintenance, the company ensures that heat pump materials are reused, rather than potentially discarded. After the first subscription year, the school has saved 25 per cent on heating expenses and reduced CO₂ emissions by 87 tonnes. Several private homes in the area have started to use the heating subscription, resulting in a 30 per cent reduction in fossil fuel consumption for the town of Hylke.

CONTRIBUTORS

Best Green
School of Hylke

LOCATION

Hylke, Denmark

Bio-based circular business models

Replacing virgin resources with bio-based resources, ultimately means designing away waste.

Sustainable consumption and production can be supported effectively by a more bio-based circular economy. Circular supply models will increase resource utilisation and promote products made from renewable biological raw materials with high recycling potential. In circular supply models, traditional material inputs derived from virgin resources are replaced with bio-based, renewable, or recovered materials, which will reduce the demand for virgin resource extraction in the long run. By making strategic sourcing decisions at the outset of product development, adopting companies can reduce environmental pressures in their supply chains, while ensuring that the materials used in their products do not eventually become waste. Essentially, waste is designed away.

Denmark, a small nation with modest natural resources, is among the world leaders in sustainable intensive food production and innovative solutions in the circular bioeconomy. The country has reduced its overall climate and environmental footprint, enhanced resource efficiency whilst increasing production and is heading towards developing more high-value products from bio-resources, for example medical products and dietary supplements.

Resource efficiency and by-product upgrading

Efficient resource utilisation and recycling, which protect land, minimise energy consumption and conserve water,

are important elements of the global agriculture and food production system. In the years from 1973 to 2017, the Danish food sector's energy consumption fell by almost 32 per cent, whilst production value increased by 60 per cent. Efficient resource utilisation can also include making optimal use of technologies and systems that increase yields in arable farming and forestry. It further entails ensuring efficient feed utilisation, fertilisation and minimising resource loss and waste generation throughout the production chain from field to the consumer.

Upgrading by-products from production processes to obtain high-value products and energy are also an essential part of the circular bioeconomy. A few practical examples that can be found in Denmark include:

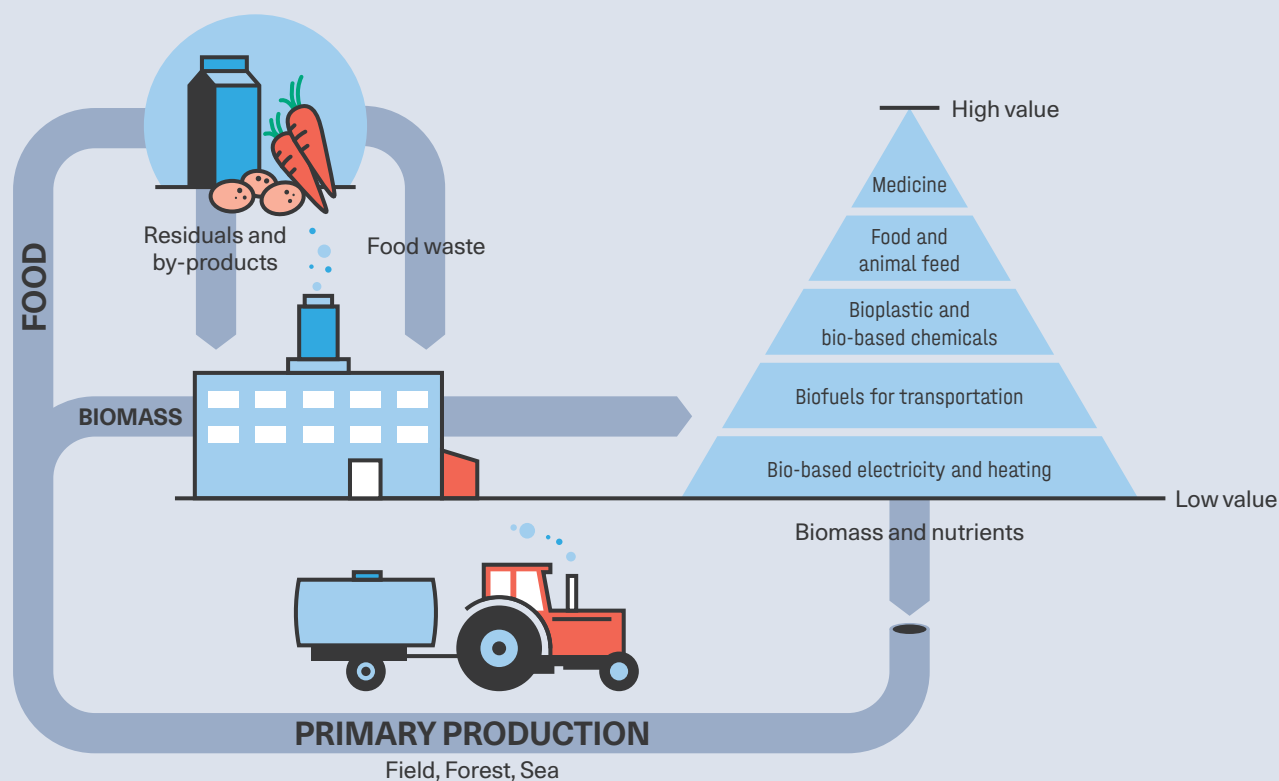
- The use of whey – a by-product from the cheese making process. The whey is converted into high-value milk powder.
- A slaughtered pig can be utilised in a total of 185 different products. In addition to the initial edible products, uses of the by-products ranges from porcelain figurines to inks.

Cascading strategy for the extended use of biomass

Processes for the full utilisation of biomass are based on cascading use and high-value products. Each biological building block must be used as many times as possible. A sustainable and circular bioeconomy aims to preserve resources at their highest value for as long as possible by cascading biomass use and recycling, while ensuring preservation of natural capital. This approach to production and consumption adopts the notion that energy recovery e.g., biomass combustion should be the last option, and only after all higher-value products and services have been exhausted. An example of cascading in practice is the development of the valorisation of the potato starch industry. The potato starch industry has developed from merely producing low-cost foods to producing an internationally in-demand food ingredient. In this way, the potato is its own small biorefinery, which ensures that all the important ingredients in the potato are separated and optimised for each of its product uses, thereby generating the highest possible economic and sustainable value.

Biorefineries for a bio-based economy

Biorefineries processing renewable raw materials are the 'factories' that valorise every component of the renewable feedstock to produce a wide range of everyday products and ingredients in the food, feed, industrial and energy outlets. They play a vital role in adding value to the principles of a truly circular bioeconomy and zero waste society. New biorefining technique extracts protein from green herbage, thereby generating maximum value out of biorefining grass – right from the field to the high-value, end products for both humans and animals. The local produced proteins can replace soy in the feed for pigs and poultry. Use of the protein in human nutrition is under development as well as valorisation of the secondary streams to provide cow feed, insulation, textiles or biochar and energy.



Sharing circular transport solution

The agriculture industry generates large amounts of residual natural fibres that currently are either left in fields for composting or incineration, used for energy production or animal feed. Essentially, end of life for the natural fibre material that could be utilised in new products, hereby extending their use, and replacing other, potentially more un-sustainable, materials with a more sustainable side stream product.

Utilisation of the natural fibre side streams not only contributes to their valorisation, but functions as a carbon storage opportunity by locking the CO₂ harvested by the plants into the product. Pond has helped companies in the horticulture, consumer goods and food industry to incorporate oat husks into its fully bio-based injection moulding resins to create rigid packaging and toddler toys that are made entirely from plant material. The oat husks are obtained from the companies own side stream or local sources and are substituting part of the bio resin to further enhance the environmental profile of the product.

Oat husks as side stream have a very low carbon footprint and pricing, hence they enable the end customer to produce products that are both greener and cheaper than without the oat husks. Valorisation is created across the entire supply chain by providing a market for a side stream, meanwhile lowering the resin raw material input to further reduce the CO₂ footprint and simultaneously nurturing the planet.



CONTRIBUTORS

Pond

LOCATION

Aarhus, Denmark

Biorefining of grass for protein production

Demand is increasing for locally produced sustainable alternatives to imported soy, as the global demand for meat is continuously high and will increase commensurate to increases in the human population. A locally grown protein based upon innovative forage solutions for feed will meet the future's needs for more sustainable meat production.

Grass, clover and alfalfa have an interesting profile for a refined protein. The protein stored in such perennial forage are, by nature, directly available to cows, and a new, innovative refining process concentrates protein from perennial forage to be a valuable protein feed for pigs and poultry. As such, a green biorefinery designed to produce protein for organic feed from approx. 2,000 hectares of perennial forage has been established in 2021 near Esbjerg. To improve the yield of protein, the company BioRefine has developed and patented a new system as an alternative to the well-known screw press system.

A breakthrough climate changing protein production means moving from imported soy to locally grown protein in grass, clover, and alfalfa. It will minimise the CO₂ footprint of the agricultural land use, as perennial forage crops are grown over 3-4 years, enabling a larger capture of CO₂ than annually rotated crops. In addition, nitrogen-fixing clover and alfalfa reduce the use of fertilisers. The capacity of the plant will be 7,000 tons of perennial forage with a 55 per cent protein content.



CONTRIBUTORS

BioRefine

DLG

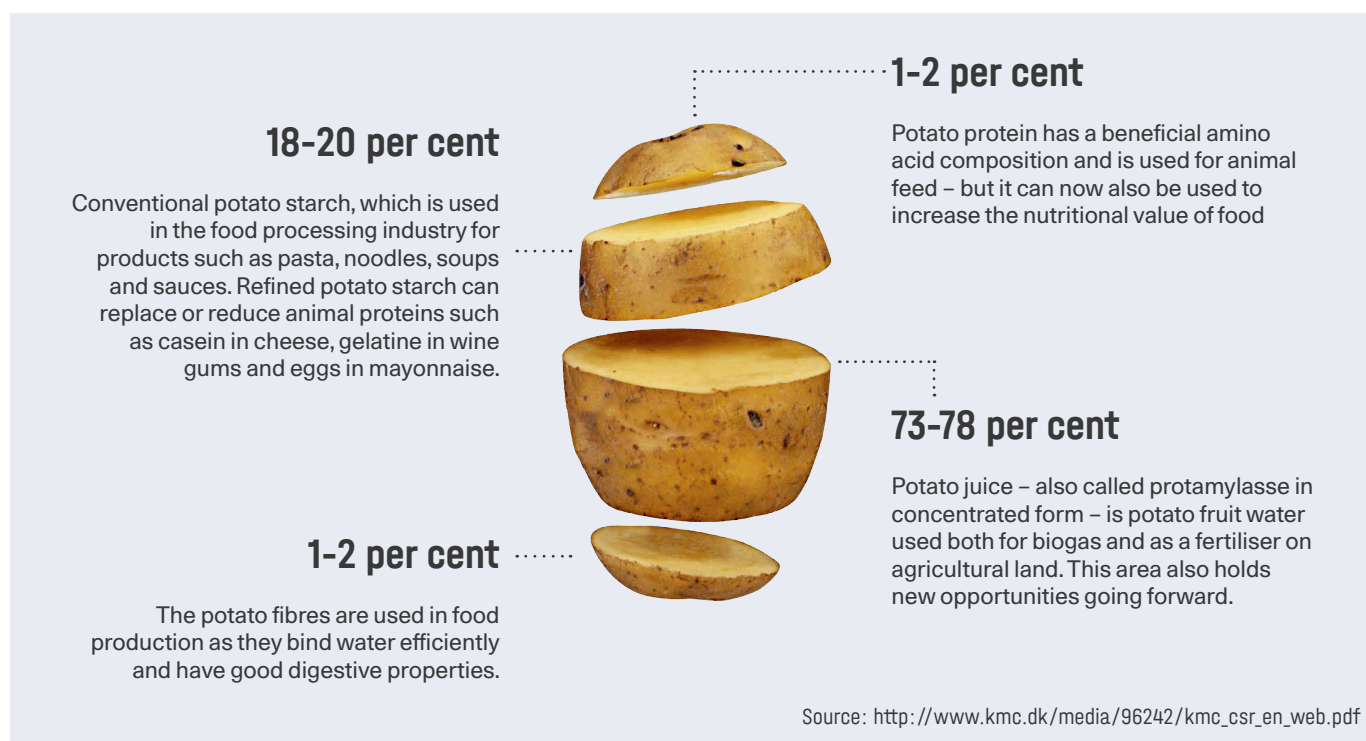
DLF

Danish Agro

GUDDP-Ministry of Environment of Denmark

LOCATION

Esbjerg, Denmark



Pioneering high-value protein feed from potato

Potato protein has a beneficial amino acid composition and is used in animal feed to replace imported animal feed protein. The use of locally produced protein can help decrease the immense global demand for animal feed protein, which has had unforeseen detrimental effects on land use and environment in some of the soy-producing countries. In addition, the use of potato protein to increase the nutritional value of food products for human consumption is very promising.

The Danish potato processing cooperative, KMC, has a long history of producing a variety of potato starch ingredients for the food industry, and has been a pioneer in adding value to its side streams. For over a decade now, KMC has been transforming residual potato fibres and protein into a valuable additive for the food industry. Splitting and refining the side streams from potato starch production helps maximise the output of each potato for the economic benefit of potato growers, thus reducing their environmental footprint, while the use of potato side streams allows the food and feed industry to efficiently increase the nutritional value of its products.

The potatoes are grown very close to the KMC factories, sometimes even on the animal farmers' own fields. In this way, a reduction of the potato's carbon footprint is achieved, as replacing conventional feed ingredients in animal feed with locally grown and refined potato protein, CO₂ intensive imports of less sustainable sources have been reduced. In 2020, 5,228 tonnes of potato protein were bought by the Danish agricultural sector alone, replacing the same amount of otherwise imported proteins such as soybeans. By 2025, a further reduction of imported feed protein is expected, as KMC aims to deliver 10,000 tonnes of potato protein to the Danish agricultural sector.

CONTRIBUTORS

KMC

LOCATION

Brande, Denmark

Circularity from use of data, digital tools, and design

The realisation of circular business models often depend on and can be scaled by the use of design, data and digital tools.

Use of data, digital tools and design of products and materials are important enablers in the development of various circular business models. Data about product design and material content, quality and origin are valuable inputs to evaluate whether a product can be better designed, reused, recycled or needs to be repaired and maintained. Therefore, data is also crucial information, when delivering the product as a service.

Denmark is a highly digitised country. Most transactions are cashless, and almost all interaction with the Danish authorities takes place online. Data on materials, product lifecycle and production currently exist, however these data are to a large extent, not yet digitalised at the level of transparency and streamlined so that they can be readily shared across value chains.

Data, digital tools, and traceability

Data on the use, location and condition of the product are important to continuously maintain and optimise the performance of the product, e.g., a rental platform can register data on the use and wear at the end of a rental period, which the producers can then use to design more durable products in the future. Another example is outdoor facilities such as bridges and buildings, where sensor data can be combined with weather and traffic data, and the use of AI to

optimise the facility's use, enable predictive maintenance and reduce operational costs.

Information on circular products and buildings are also important for sustainability documentation and reporting, which increasingly are considered a competitive advantage for businesses. Large companies and investors are demanding documentation from suppliers regarding, whether their activities are sustainable. For companies and businesses to collect, use and share data for business development and documentation, they need supportive digital tools. There is a growing market for enablers delivering software and blockchain solutions for data sharing about materials and traceability as well as on product performance.

Designing for the circular economy

Design refers to the way products, services and systems are created. The circular design of products is crucial in the development of circular business models, products, and buildings. According to the European Commission, more than 80 per cent of a product's environmental impact is determined in the design phase. New value can be unlocked for both producers, constructors, and consumers by designing products and buildings to be easily reused, repaired, refurbished, remanufactured, or shared.



Credit: Unsplash

Design is also central for delivering a product-as-a-service giving access to the use of a product, rather than selling the product, through rental, subscription, sharing or leasing schemes. Design – or redesign – is central, when giving used clothes a second life. Design can also be used strategically to connect customers more closely to the product, the store, and/ or the manufacturer, to enable a stronger commitment to the product, which can increase the use period. A few additional examples of the role of design include:

- Plastic packaging can be designed to be recycled at high value when it is produced with only one type of plastic rather than a mix, impairing recycling.
- A building can be designed for circularity if it is designed to be easily decommissioned, e.g., using principles of modularity and design-for-disassembly to enable higher reuse of the building materials.
- Design has an important role to play to enable sustainability in the fashion industry where production has doubled worldwide from 2000 to 2015 and the average customer buys 60 per cent more clothing than they would 15 years ago and only uses it for about half as long. This dramatic development is not sustainable and can be

reversed by using design to change customer consumption patterns, e.g., by designing for better use of clothes, using sharing and rental platforms.

- Strategic use of design could for instance be a restaurant or food delivery business that supplement their offer with opportunities for the customer to meet and eat together with the food producers to provide the customer a deeper understanding of the process of producing food and the importance of doing so sustainably. Another example is inviting clients to be investors and co-responsible in supporting sustainable local production.

The use of data, digital tools, and strategic design can be found at the core of the business models for circular economy; product life extension and reuse, recycling of waste, product-as-a-service and sharing business models. Incorporating circular economy principles in the design of products is central, as this optimises products or services' ability for enhanced use. Data on the product enables evaluation and improvement. Digital tools enable the use and shareability of the data for traceability and assure quality for reuse, recycling and management of products based as product-as-a-service or in a sharing business model.

Blockchain enabled 100 per cent traceable leather

The hides used for the production of leather are by-products of the meat and dairy industry, meaning that leather production is essentially a waste upcycling process that creates a durable material that can be further used in the fashion and lifestyle industry. However, as consumers place greater demands on brands to provide information about where and how their products are made, the lack of traceability in the leather industry is proving to be a major challenge for leather suppliers and brands who use leather in their products. In collaboration with SPOOR, a brand of Scan-Hide which is the only tannery left in Denmark, Danish shoe brand Roccamore has launched its first shoe collection made with premium leather that is 100 per cent traceable, right back to a single animal.

SPOOR marks each hide with a unique number, which is resistant and stays on the hide throughout the entire tanning and refinement process to the final leather cut and provides the full backstory of the animal. Details include the country of origin, breed, birthplace, and the abattoir where the animal was slaughtered. The collaboration uses blockchain technology to demonstrate transparency, and each shoe includes a QR code which takes the customer on the entire journey from the fields of Jutland to Scan-Hide, to the finished tannery, to the manufacturers in Tuscany and back to Denmark. The technology offers Roccamore and other brands alike the full backstory of the individual animal that has supplied the leather they use. In this way, brands can not only trace the origin of each hide, but they can also use this data to substantiate their policies on product quality, animal welfare, environmental protection and social responsibility.



CONTRIBUTORS

SPOOR
Scan-Hide
Roccamore

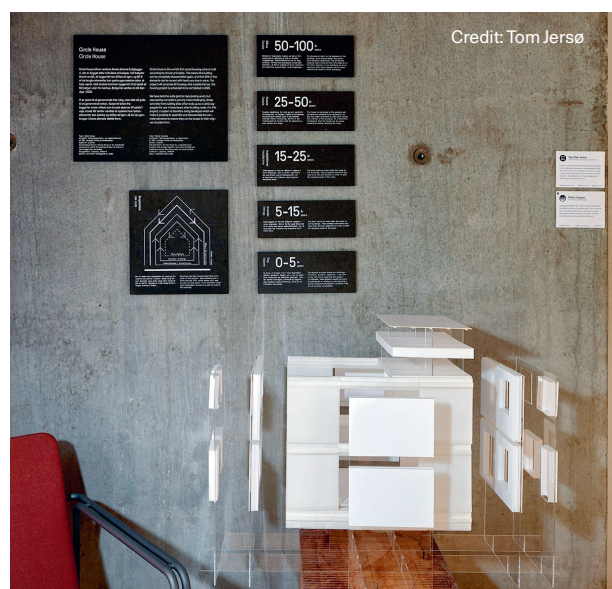
LOCATION

Vester Skerninge, Denmark

Designing housing for disassembly and reuse

Circularity and reusability are decided already in the design-phase, as clearly manifested in the soon to be completed Circle House project outside the city of Aarhus. Circle House is building 60 social housing units constructed after circular principles and marketed on normal terms. The aim is that 90 per cent of building materials are reusable without considerable loss of value. In essence, Circle House is designed to one day be disassembled, rather than demolished.

Renovation and demolition of buildings account for 27 per cent of waste produced in Denmark. Today's buildings and building components are often cast and glued together, making separation and reuse of materials impossible. Designing housing that enables separation, by e.g., bolting together pre-cast elements, not only makes reuse possible, but also increases repairability, prolonging the life of the buildings. Circle House brings together over 60 different companies, who all offer circular solutions, ranging from the structural elements to the movable objects inside such as circular furniture, curtains, and lamps.



CONTRIBUTORS

Lejerbo, GXN Innovation, 3XN Architects,
Lendager Group, Vandkunsten, MT Højgaard,
Danish Environmental Protection Agency, Realdania

LOCATION

Aarhus, Denmark

Retrofitting conventional energy-intensive lighting with energy-efficient LED

Lighting fixtures for commercial and public construction are currently designed to suit a linear economy where the solutions have a limited lifespan and cannot be repaired. At the same time, millions of existing light fixtures made of high-quality materials are discarded simply due to the interior electronics being outdated. This results in unsustainable resource expense, which contravene the goals of the Paris Agreement.

Lighting manufacturer, Fischer Lighting, have designed their lighting solutions to enable retrofitting of currently owned lamps to a more energy-efficient light source, hereby ensuring reuse. Additionally, their own lighting fixture designs are based on and enable disassemble and repair as well as recyclability. All parts can be separated and re-used, reducing carbon emissions by up to 42%, in comparison to newly produced lighting fixtures. Any electronic parts that are replaced in production, are sent to an upcycling facility ensuring recycling of the material.

Coloplast, a Danish medical equipment manufacturer, was faced with this lighting challenge as they were looking to improve the energy-efficiency at one of their offices. Here, existing lamps, were retrofitted with LED and renewed rather than discarded, optimising the energy use for Coloplast. Total energy savings amounted to 67 per cent, whilst reduction of CO₂ emission was 7.2 tonnes, totalling a cost-saving of EUR 27.000.



CONTRIBUTORS

Fischer Lighting
Coloplast

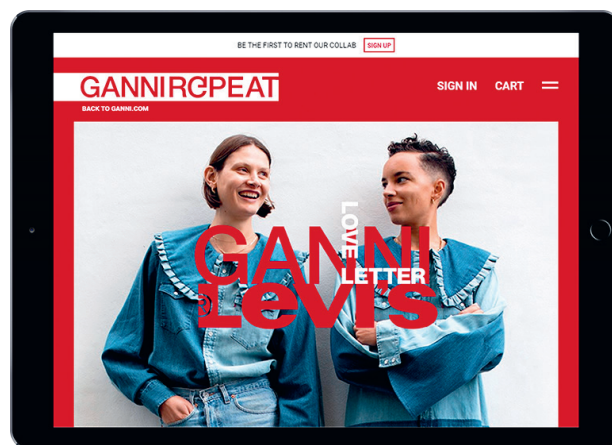
LOCATION

Espergærde, Denmark

Digital product-as-a-service platform turning challenges into business opportunity

Fashion consumers are increasingly demanding responsible actions from brands and their products whilst resource scarcity is becoming an increasing challenge for the fashion industry. Currently, the EUR 18 billion resale apparel market is growing 24 times faster than the retail apparel market. It is estimated that recirculating clothes is the most efficient way of reducing the fashion industry's footprint, as it is up to 3000 per cent more efficient than reusing materials to produce new clothes.

Turning that challenge into a business opportunity, global fashion brand GANNI collaborates with the digital product-as-a-service-platform, Continued Fashion to ensure recirculation. The fashion brand has chosen to rework and reuse fabrics from previous collections prior to recirculation, creating a one-of-a-kind collection on the easily integrated, brand-labelled digital platform provided. The platform enables fashion brands to offer circular retail business models such as rental or peer-to-peer resale to their customers. It allows the GANNI clothes made from excess fabrics to circulate among customers, increasing profit per product, effectively reducing the resource footprint for the purchased fabrics. The digital platform and inherent circular business model enable brands to gain a more resilient resource supply and reduce environmental impacts through product life extension and reduced resource consumption.



CONTRIBUTORS

Continued Fashion
GANNI Repeat

LOCATION

Copenhagen, Denmark

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

www.stateofgreen.com

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Danish Ministry of Climate,
Energy and Utilities



Ministry of Environment
of Denmark



MINISTRY OF FOREIGN AFFAIRS
OF DENMARK