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INNOVATIVE TECHNOLOGY

STEERING THE GREEN AGENDA IN FARMING AND FOOD

INSIDE THIS WHITE PAPER:

- **The value of connecting knowledge**
- **Sustainable growth through smarter farming**
- **Powering efficiency with process automation**

FOOD NATION
Solutions of tomorrow
By Denmark

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Innovative Technology

Steering the green agenda in farming and food
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EXECUTIVE SUMMARY

Denmark has a long history of developing new tools and techniques for overcoming challenges in food and agricultural production. This tradition for innovation is rooted in the Danish collaborative culture, which can be traced back to the founding of the first dairy cooperatives in the mid-1800s.

The food and agriculture industry relies on technology to reduce energy and water consumption and recycle wastewater and heat. Significant progress is being made

Today, farmers, food manufacturers, knowledge centres, research institutes, technology specialists and government authorities play a central role in maintaining the pace of technological innovation.

Denmark is a role model for high production yields and resource efficiency and, as such, a major exporter of technology that supports the green transition of the global food value chain.

While farmers increasingly employ precision agriculture to minimise their environmental footprint, food manufacturers are heading towards more digital solutions. The age of automation heralds higher standards of food safety and quality and better, safer working conditions for operators. Advanced predictive maintenance tools keep production lines efficient and competitive.

As large-scale consumers of water and energy, the food and agriculture industry relies on technology to reduce consumption and recycle wastewater and heat. Significant progress is being made. In the move towards a circular economy, livestock manure and side streams from food production have become the feedstock for Denmark's growing biogas production – an energy source that is gradually replacing fossil fuels as part of the renewable energy mix.

This white paper shares insights into the innovative technology that already makes the Danish food cluster a global front-runner and the visionary thinking that will become the next innovation.

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INDEX

Supporting the SDGs
How does Denmark contribute?

The UN's 17 Sustainable Development Goals have provided a common framework for overcoming the world's most pressing challenges. Along with many other stakeholders, the Danish food and agriculture sector has taken the SDGs on board. Today, they serve as a guiding light for establishing best food production practices, prioritising research and development efforts and identifying innovation targets to drive us towards a sustainable future.

There are some goals where Denmark is expected to make a particular impact via agri-food strongholds such as innovative technology. These include **Goal 2** *End hunger, achieve food security and improved nutrition, and promote sustainable agriculture;* **Goal 6** *Ensure availability and sustainable management of water and sanitation for all;* **Goal 12** *Ensure sustainable consumption and production patterns;* and **Goal 13** *Take urgent action to combat climate change and its impacts.*

Achieving the ambitious goals of the 2030 agenda requires global support and partnerships. Extensive collaboration throughout the food value chain and between industry, academia, NGOs and government is an outstanding characteristic of the Danish food cluster. By accelerating the progress of national and international initiatives, such united efforts directly contribute to **Goal 17** *Strengthen the means of implementation and revitalize the global partnership for sustainable development.*

SUSTAINABLE DEVELOPMENT GOALS

FOREWORD

Photo: Steen Brogaard

The global food supply is at a turning point. As climate change, population growth and a heavy reliance on natural resources make an impact, the need for new approaches to food and agricultural production is abundantly clear.

New technology is one of the motors that will drive this transition. Despite our nation's small size, we in Denmark have a long track record as world leaders in innovative solutions.

We find ourselves in a time where the United Nations Sustainable Development Goals have become more relevant than ever. As always, the Danish food cluster is ready and prepared to make a positive contribution.

Ambitious emissions goal

The Danish government has set ambitious goals for the transition to a greener, more sustainable future – to reduce greenhouse gas emissions by 70% in 2030, based on 1990 levels, and to be carbon neutral by 2050. Denmark's food and agriculture sector is playing a vital role. The focus is on developing innovative technology to reduce the use of scarce resources while producing more food for growing world needs.

For decades, tough environmental protection regulations have regularly tested the resourcefulness of Danish farmers and food producers. As a result, the food and agriculture sector has earned a reputation for environmental efficiency. Farmers have successfully increased their yield while reducing their nitrogen discharge and use of pesticides and antibiotics. Food processing companies have become increasingly skilled at recycling surplus heat and wastewater, while raw material side streams are captured and repurposed.

Danish food and agriculture owes much of its strength to this long tradition for innovation. The sector is well-tuned to find new ways to reach government-set targets and meet the growing global demands for food and for more traceability, transparency and trust in the food supply chain.

Relieving the strain on nature

Effective innovation requires the ability to think ahead, foresee emerging needs and draw on the right competences to develop new technological solutions. In Denmark, our innovative tradition within food and agriculture dates back to the mid-1800s when dairy farmers pooled their resources in the first cooperatives.

Efficiency improvements are vital to relieve the strain on natural resources and the climate. Wherever you look in the Danish food and agriculture sector, it is possible to find examples of technological ingenuity that reduce water and energy consumption, cut carbon emissions and maximise raw material utilisation. To reduce the use of fossil fuels, food and agricultural waste has become the feedstock for biogas production.

The next frontier

Digital technology is the next frontier for sustainable food production. Here, too, Danish technology providers are leading the way with, for example, robots and predictive maintenance for smart food processes and GPS and drone technology for crop management.

Continuous innovation is key to the green transition and overcoming future sustainability challenges. In Denmark, we have the ability and the will to keep up the momentum.

Rasmus Prehn

Minister for Food, Agriculture and Fisheries

CHAPTER 1

THE VALUE OF CONNECTING KNOWLEDGE

A LONG TRACK RECORD FOR LEADING TECHNOLOGICAL DEVELOPMENT

Foto: Food Nation

Denmark's reputation as a technology pioneer has firm roots in the country's collaborative culture.

Collaboration between Danish universities, businesses, industry associations and the government is a core pillar of successful innovation

Photo: Food Nation

More than a century ago, Danish farmers saw a need to develop new ways to make more efficient use of farmland and livestock and to maximise product quality and yield. Another key priority was to preserve the integrity of the soil. As the global food supply chain has grown in complexity, these fundamental considerations have become more important than ever – and the need for technology to secure food safety, quality and sustainability is increasingly intense.

This is where the Danish food and agriculture sector makes a strong contribution. Thanks to the early focus on collaborative research and development, the sector is a role model for technological innovation and resource efficiency. Our ability to make more with less – while raising quality and safety standards – is the reason why we now produce enough food to feed the Danish population three times over.

Increased focus on digitalisation

In the mid-1800s, small Danish farmers faced increased competition from larger farms in other countries. By pooling their resources and building factories that could produce uniform, high-quality products faster and more efficiently, they founded the cooperative movement that strengthened their competitive ability in international markets. The enhanced focus on food safety and quality enabled the continuous development of technological solutions to meet new demand.

Today, collaboration between Danish universities, businesses, industry associations and the government is a core pillar of successful innovation. One area of major current interest is industry 4.0 – the fourth industrial revolution where the physical and digital worlds are increasingly merging.

Between them, digital specialists and experts in agri-food production are developing sensors, artificial intelligence, drones and satellite technology – and making the benefits of smart data management accessible. This empowers better decisions, smarter and more sustainable production, and the ability to track and control the food value chain from raw material to consumer.

Cluster power

Denmark is now a digital leader, ranking third in both the IMD World Digital Competitive Ranking 2020 and the European Digital Economy and Society Index 2020. Against this backdrop, entrepreneurs will find generous support schemes and a vibrant tech startup community. The X-Tech Food & Ag Programme, operated by DTU Entrepreneurship at the Technical University of Denmark, and the Rockstart Agrifood accelerator are examples of startup environments that specifically encourage food and agriculture innovation.

According to a survey by Cluster Excellence Denmark, companies that participate in clusters increase their innovation power fourfold. Denmark is home to many hotspots where established companies and startups combine their knowledge and expertise to reach the next level of innovation. One of the world's top centres for robotic and automation technologies is among them.

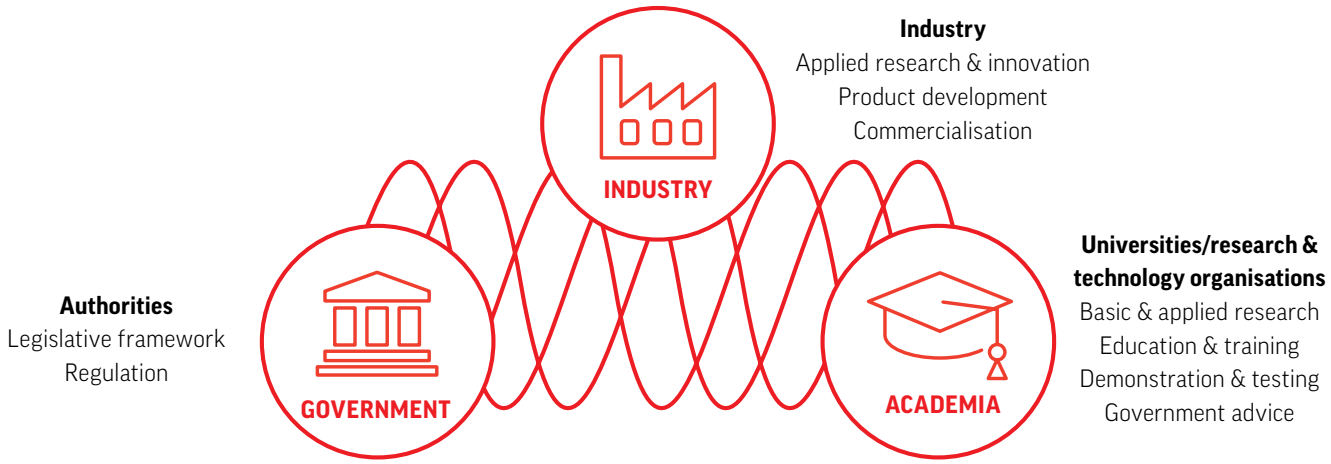
From research to value

Close interaction between the public and private sectors speeds up the journey from innovative research to successful commercial products. Seven Danish government-approved research and technology organisations play a key role in this knowledge transfer, ensuring the latest technology is smoothly and efficiently put to best use.

Similarly, the farmer-owned agricultural knowledge centre SEGES, which is part of the Danish Agriculture and Food Council, helps to bring the latest knowledge and technology to farmers as quickly and efficiently as possible. By using applied science from the universities and facilitating meetings between farmers and commercial companies, new products are tested and modified from an early stage of their development.

Collaboration continues to be the lifeblood of technological progress in Denmark. Mutual trust, openness and a willingness to share drive innovation at all levels of the agri-food value chain.

The triple helix model



INTERNATIONAL PARTNERS ACCELERATE DETECTION OF POULTRY DISEASE

Rapid detection of pathogens and viruses is vital in the poultry industry to avoid outbreaks of salmonella, campylobacter and bird flu that are a risk to consumer health and may lead to expensive losses for producers.

Farmers and food producers currently rely on traditional test methods, which involves sending samples to a laboratory for analysis and waiting for up to two days for the results. Due to the speed at which infectious diseases spread, the delay may have critical consequences.

> Thanks to the fast result, farmers and food producers will soon have the opportunity to contain and eliminate undesirable microorganisms from a much earlier stage

Fast analysis on location

The Technical University of Denmark (DTU) teamed up with partners in Sweden, France, Germany and Italy to develop a solution. Together, they came up with Vetpod, a portable device that can detect pathogens and viruses in poultry flocks or fresh meat processing lines in less than an hour.

Photo: FVST

Vetpod contains a specially designed chip, so throat or rectal samples from the animals can be analysed on location. Thanks to the fast result, farmers and food producers will soon have the opportunity to contain and eliminate undesirable microorganisms from a much earlier stage.

Developed as part of the EU-funded VIVALDI project, Vetpod is expected to become commercially available in the near future.

Case by Technical University of Denmark

EXPERTS CO-DEVELOP FLEXIBLE MEAT TRIMMER

Producing uniform, high-quality pork loin is no longer a challenge using 3D trimming technology developed by the Danish Meat Research Institute in partnership with machine manufacturer Frontmatec and the meat processing companies Tican and Danish Crown.

Their advanced and fully automated machine is designed for precision trimming of the fat layer on pork loin, improving quality and reducing waste.

For slaughterhouses, the machine overcomes a long-standing challenge – the reliance on manual evaluation of the meat by slaughterhouse workers, who then determine the thickness of the fat layer on, for example, back bacon for the UK market.

The advanced and fully automated machine is designed for precision trimming of the fat layer on pork loin, improving quality and reducing waste

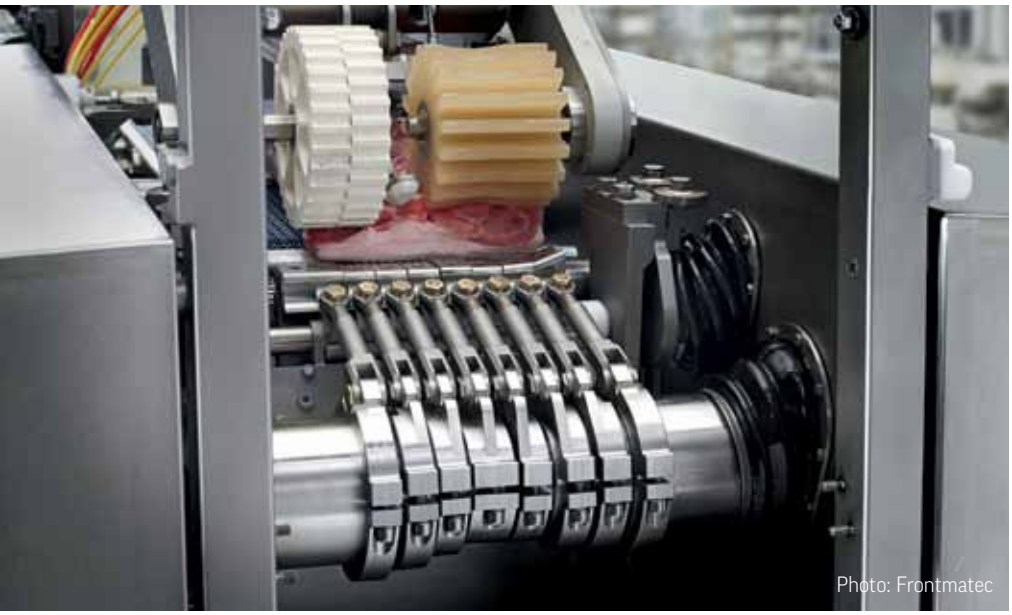


Photo: Frontmatec

Four-second process

The solution starts with the machine computer, which generates a precise 3D picture of each pork loin to determine where fat and meat intersect. Based on that information, a patented automated knife system then cuts the loin fast and efficiently. The whole process takes just four seconds per joint.

The technology adapts easily to the varying needs of individual markets, resulting in pork loin that always meets expectation and makes the best possible use of the meat.

Case by Danish Meat Research Institute (DMRI)

CROSS-SECTOR RESEARCH UNLOCKS A GREEN PROTEIN

A new biorefining technique has unlocked the high protein content of Danish clover grass and will soon make it available in feed for organic pork and poultry producers.

Containing more than 40% protein and all the right amino acids, clover grass has great potential as locally sourced nutrition feed. Results from livestock feeding trials have proven that the extracted protein is an efficient alternative to soya meal in pig and poultry feed.

The technique has been co-developed by research partners from the private and public sector and involves squeezing large amounts of freshly and finely cut clover grass in a screw press. The juice is then transferred to an acid tank, heated and fermented using a lactic acid culture.

Concentrated protein is removed from the juice by centrifugation. Residues from production can also be used to feed cows and fuel biogas plants.

Once ready for commercial launch, the green protein feed will provide organic and conventional farmers with an additional, locally produced supply of essential nutrients for their livestock.

Case by SEGES
Danish Agriculture & Food Council F.m.b.A.


Photo: SEGES, Danish Agriculture& Food Council

Containing more than 40% protein and all the right amino acids, green herbage has great potential as locally sourced nutrition

CHAPTER 2

SUSTAINABLE GROWTH THROUGH SMARTER FARMING

PRECISION AGRICULTURE MAKES STRONG FARM BUSINESSES

Photo: Farmdroid

Danish agricultural technology has taken giant strides over the years – improving efficiency, increasing yield and optimising animal welfare.

Modern Danish agriculture has grown up with the need to make efficient use of limited farmland. Since 1990, farmers have increased their yield by almost a third while complying with Danish and EU regulations on nutrient discharge into inland and coastal waters. Such an achievement is the outcome of an eminent ability to develop and apply the latest technology.

This expertise is the backdrop to Denmark's successful exports of advanced agricultural technology for conventional and organic farming. Manure spreaders, feed mills and barn ventilation systems, for example, are tailored to the needs of farmers all over the world – supporting their implementation of effective, resource-saving agricultural practices with a reduced carbon footprint.

Opportunities for green precision

In recent years, precision farming has brought a whole new range of opportunities to improve the sustainability of crop cultivation. Across Denmark, use of this technology is becoming increasingly widespread among farms of all sizes.

On tractors and slurry machines, a GPS tracking and monitoring system can ensure herbicides and fertilisers are applied in the right dose and that seeds are sown at the right depth for optimum growth. The farmer-owned agricultural knowledge centre SEGES develops a number of tools that enable farmers to hook up with satellites and benefit from this dosing precision.

A growing number of farmers rely on field robots to improve their efficiency. Using a vision-based hoeing machine, for example, farmers can supervise weed control in row crops from a smart phone or laptop. In the years ahead, drones will become an increasingly familiar sight, as they fly over fields to identify weeds and ensure targeted use of herbicides.

Technology of this kind benefits the environment, improves yield and reduces farm costs. In other applications, it can reduce waste of valuable raw materials. One example is the automated feeding systems that both mix and deliver feed to meet the specific nutritional requirements of livestock – reducing feed loss and increasing farm profitability.

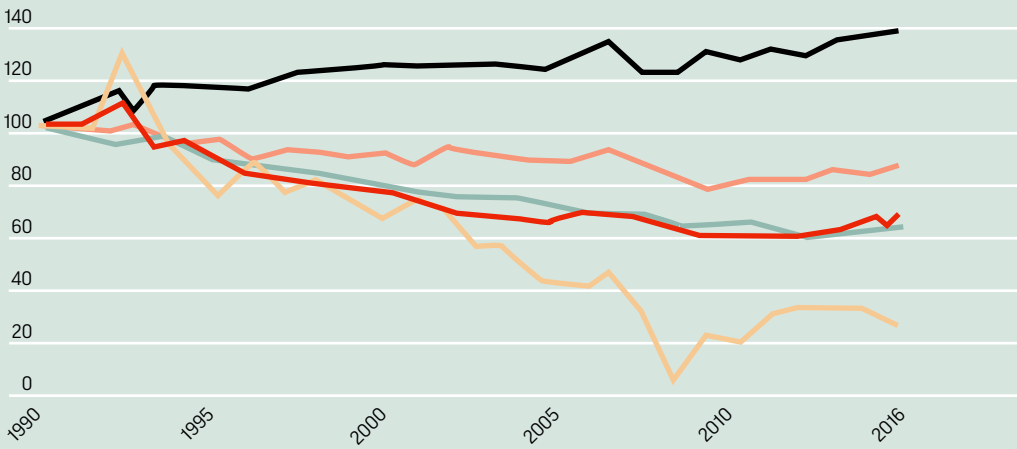
Correct raw material transportation and storage are also important factors in loss minimisation. For this reason, Danish companies have developed enclosed silos to control the temperature and humidity of stored grain, protect against insects and remove impurities such as weed seeds. The silos significantly reduce the volumes of grain that go to waste post-harvest. This is a valuable advantage in a hungry world where a third of global food production is either lost or goes to waste, according to the Food and Agriculture Organisation (FAO).

Smart improvements in animal welfare

With the arrival of digitalised barn systems, farmers have gained new possibilities to improve the health and living conditions of livestock. Smart monitoring systems, for example, alert pig producers to farrowing sows, minimising the number of stillborn piglets when complications arise. Developed by Danish knowledge institutions, an online communication platform enables cattle farmers to register and share knowledge with nutrition advisors and veterinarians. Feed is adapted to cattle requirements based on data collected by sensors in the barn.

Efficient animal production requires optimum conditions. One of many important factors for animal growth is barn climate, which can be optimised by ventilation systems. This is where farmers benefit from a farm management system that provides a total overview of energy use and provides the basis for continuous efficiency improvements.

Since 1990, the Danish food sector has both increased production and reduced its environmental impact (1990=index 100)



Source: DCE reports no. 270 and 273 (2017); DCE: Agriculture (http://envs.au.dk). UNFCCC: National Inventory Submissions 2016; Statistics Denmark national accounts; EIONET. Central Data Repository: A. National emission inventories (CLRTAP).

HIGH-YIELD CROPS GO SMART AND SUSTAINABLE

Samson Agro has applied the latest technology to its agricultural machines for more than 75 years. The challenge is always to meet farmer needs to increase crop yield, make efficient use of the nutrients in manure and reduce their environmental impact.

To ensure product innovation of the highest possible standard, Samson Agro partners with universities and other research organisations. As a result, the company has been able to expand its smart farming technology with a GPS solution for variable slurry application based on GPS mapping. The solution is combined with a nuclear magnetic resonance sensor system that takes precise real-time measurements of nutrients such as nitrogen, phosphorus and potassium in the natural fertilisers. In this way, farmers can be sure that slurry spreaders distribute nutrients precisely, according to the requirements of each field section.

Photo: Samson Agro

> By maximising the use of animal manure, farmer reliance on chemical fertilisers is reduced – along with their environmental footprint

Digital solutions that prevent nutrient overuse are the sustainable way to higher farm yields and profits. By maximising the use of animal manure, farmer reliance on chemical fertilisers is reduced – along with their environmental footprint.

Samson Agro is a Danish example of a global green tech company that leads the way with the development and sale of high-quality agricultural machinery. Wherever farmers are located in the world, Samson Agro designs machinery to give the highest yield.

Case by SAMSON AGRO

LESS FOOD LOSS WITH ARTIFICIAL VISION

Innovative technology from Cimbria Unigrain is tackling two major challenges for the food industry – the need to improve food safety and reduce food loss to a minimum.

As a world leader in grain handling and seed processing technology, Cimbria Unigrain has specialised in developing advanced solutions that sort and grade seeds, protect crops from post-harvest spoilage and, through that, effectively reduce waste.

Sea Chromex is one example. A full-colour vision system combined with near-infrared technology, it represents the most advanced vision-based seed and grain sorter on the market – capable of recognising and separating the tiniest defects in colour, shape and size, which are invisible to the human eye.

> Advanced solutions that sort and grade seeds, protect crops from post-harvest spoilage and, through that, effectively reduce waste

Cimbria Unigrain has incorporated InGaAs technology in Sea Chromex to enable precise removal of hidden flaws, such as grain contaminated with mycotoxins or sclerotium, unshelled grain or fragments of nutshell.

In this way, the quality of grain and seeds reaches a new level of excellence. Grain meets the highest standards for food and feed safety, and damaged seeds with low germination potential are removed. The reduction of loss also cuts costs – a major benefit for the agriculture sector and the food supply chain as a whole.

Case by CIMBRIA UNIGRAIN

Photo: Cimbria Unigrain

A WELL-VENTILATED LIVESTOCK HOUSE BOOSTS PROTEIN PRODUCTION


Photo: SKOV

A stable indoor climate is particularly important to animal growth, performance and welfare

Growing global demand for protein has intensified the need for efficient livestock production on the farm. A stable indoor climate is particularly important to animal growth, performance and welfare.

Danish SKOV A/S has built an international reputation for energy-efficient and reliable climate systems that adapt to local conditions and farming methods all over the world.

Today, SKOV has consolidated its leading position by integrating the latest digital farm management solutions – making it possible to monitor and adjust temperature and humidity around the clock.

Efficient ventilation optimises production conditions, improves productivity and contributes to better animal welfare, which is another increasingly important factor in livestock production.

A well-managed indoor climate benefits the environment, animal welfare and farm owner profits.

Case by SKOV

REAL-TIME INSECT MONITORING PROTECTS CROPS AND BIODIVERSITY

Insect pests are the cause of significant crop damage and loss. The challenge is that regular monitoring is labour intensive and expensive. At the same time, it is important to control pests without removing essential pollinators and other beneficial insects. So, the ability to monitor insect populations systematically, efficiently and accurately is key.

The start-up company FaunaPhotonics is building real-time insect monitoring technology to support integrated pest management, including timely treatments and intelligent spraying equipment. The technology platform combines patent-protected sensor technology with artificial intelligence to differentiate between insect species.

> Monitoring insect populations systematically, efficiently and accurately is key

Smart insect classification

A sensor placed in the field uploads real-time insect activity to a cloud database. Artificial intelligence classifies the insects, so farmers can see when pests, pollinators and other beneficial insects are in the field – and can time insecticide spraying accordingly. The information is readily available via a digital platform.

FaunaPhotonics develops its systems in collaboration with growers, agricultural consultants, corporate R&D departments and scientists. This ensures customer needs are met in an affordable digital solution that monitors insects accurately and efficiently worldwide.

Case by FaunaPhotonics

Photo: FaunaPhotonics

CHAPTER 3

POWERING EFFICIENCY WITH PROCESS AUTOMATION

RELIABLE QUALITY FROM INPUT TO OUTPUT

Photo: Food Nation

High-tech automation holds the key to efficient, high-capacity food production with the highest standards of quality, food safety and traceability.

Danish manufacturers of innovative processing equipment stand out for their strong presence on the global market. Their ability to develop new technology in close collaboration with food producers is an essential skill, as the food industry continuously seeks new ways to reduce production costs and meet environmental demands while staying competitive.

> Danish technology companies can offer new smart solutions for industrial automation and data management systems that support efficient and standardised food production and packaging

Denmark has attained a strong international position as a food technology provider as a result. In a ranking of 30 global science and engineering regions, both Aarhus University and the Danish Meat Research Institute are in the top six among universities and research institutions that file most patents.

Today, Danish technology companies can offer new smart solutions for industrial automation, including robots, sensors, quality analysis technology and data management systems that support efficient and standardised food production and packaging.

Fully automated, streamlined factories enable reliable and rapid handling of large volumes. Within the fishing industry, for example, it is now possible to automate processing onboard the ship and off using a range of sophisticated equipment.

The pros of automation are many. Process operators benefit from better and safer work conditions with less risk of human error, while food safety and quality are improved. Automation of internal transport improves efficiency and increases capacity. Industrial robots contribute to more stable production and uniform product quality. Overall, the productivity gains for the entire value chain are significant.

Following the onset of the COVID-19 pandemic, automation has gained further traction as a means to improve hygiene and protect operators from infectious disease by enabling social distancing on the factory floor.

Robots and cobots

Danish food technology companies have come far in the field of industrial robots, including the development of compact and flexible collaborative robots – called cobots. In addition to supporting faster, more accurate food production, they can take over manual jobs, where operator health is likely to suffer from monotonous routines. Risks of contamination and human error are similarly reduced.

Examples include self-learning robots for cutting meat. Through the continuous gathering of data, cuts of meat become more precise and refined. Machine vision systems are increasingly used to guide robots and monitor quality.

Efficiency through predictive maintenance

A top priority for all food processors is to minimise unscheduled production downtime due to problems on the line – a cause of expensive delays and raw material loss. This is why Danish suppliers also lead the way with digital solutions that monitor processing efficiency and predict the need for line maintenance before a breakdown occurs. Using cloud-based predictive tools, manufacturers can secure better performance and a longer lifespan for their equipment, further contributing to sustainable operations.

Securing food safety and quality

Another critical factor is to ensure the highest standards of food safety by avoiding product contamination – either by the raw materials that arrive at food production plants or by insufficient cleaning of processing equipment.

In the dairy industry, for instance, milk deliveries can be contaminated by harmful bacteria. Critical control points throughout the value chain are key to establishing the necessary traceability to manage and reduce this risk. Using bacterial analysers, dairies can test the bacteria in raw milk fast, reliably and at low cost – before the milk enters the plant.

At the other end of the production line, innovative technology enables instant quality analyses of liquid and semi-solid dairy products – such as milk, cream, whey, ice cream, desserts and yoghurt. This provides dairies with strong tools for safeguarding consumers against sub-standard or adulterated food products and meeting the demand for farm-to-fork traceability.

HIGH-SPEED ROBOTS HANDLE 800 CANS A MINUTE

Photo: ABB

Integrated vision software ensures every can lives up to the factory's high quality standards

Up to 107 million cans of mackerel roll off the production lines at Sæby Fiske-Industri every year. A high-speed packing system, delivered by VARO, ensures each can is sorted and securely packaged before dispatch, primarily to supermarkets throughout Europe.

ABB has supplied the five FlexPicker robots on each of the two fully automated packing lines. Between them, they handle 800 cans a minute – more than 700,000 a day. Integrated vision software ensures every can lives up to the factory's high quality standards.

Meeting complex needs

For automated equipment supplier VARO, ABB's FlexPickers were the optimum choice for carrying out complex sorting and packaging tasks. As Sæby Fiske-Industri is Europe's leading producer of private label canned mackerel, the robots are critical for ensuring a fast and smooth switch between the many packaging types and patterns for packaging and palletising.

The packing system is also equipped with an X-ray device that detects metal and other foreign materials before the cans are sent for date printing and to the vision unit, which checks for any deviations on the actual can.

Since installing the packing lines, Sæby Fiske-Industri has improved efficiency and eliminated manual tasks that cause repetitive strain injury. Employees can now focus on other work, including servicing the robots and filling boxes at the packing stations.

Case by ABB

EFFICIENT FOOD PRODUCTION NEEDS A DIGITAL TWIN

Demands on efficiency, traceability and food safety are growing fast in industrial-scale food production, and that often calls for major investments in new or upgraded facilities. Danish consultant engineering company Niras has developed a digital tool to help manufacturers take the risk out of their investments.

The tool is a real-time, virtual simulation of the production process, line or plant – a digital twin, where all parameters can be fine-tuned for the best possible performance. Using this technology, manufacturers can then design and build complex production facilities in real life, often at lower cost.

Niras is building a strong track record in the field. For one dairy that needed a new micro-dosing system, the investment cost was cut by EUR 630,000 after a digital twin validated and optimised the design.

Continuous monitoring

Once a new processing line is in operation, the digital twin can continue to inform manufacturers about potential problems so timely adjustments can be made and preventive maintenance carried out. When new equipment is added or there is a change in the product mix, the digital twin can also predict the impact, including the risk of bottlenecks elsewhere on the line.

Photo: Niras

In one dairy assignment, a digital twin was used to validate and optimise the design of micro-dosing equipment for a new powder blending section. Bottlenecks were identified and removed, cutting the investment by EUR 630,000 in just three weeks of simulation work.

Niras has also successfully designed digital twins for the brewing, dairy, meat, poultry and fish industry.

Case by Niras

> By using a digital twin, manufacturers can design and build complex production facilities in real life at a lower cost

AUTOMATED TRACEABILITY IS THE KEY TO PREMIUM MEAT

Photo: Frontmatec

> Accurate traceability is key to guaranteeing the quality and food safety of premium meat products

Traceability is crucial when managing the production of high-end meat products and ensuring optimum use of raw materials at the same time. The automation experts at Frontmatec understand that need completely. Their tailored software solutions for modern meat processing companies are the proof.

Based in Denmark, Frontmatec is a world-leading supplier of customised automation solutions for the food industry.

Frontmatec's GOSystems are designed to to record every step in the production cycle from raw material reception to packing and final product dispatch. Through carcass grading, slaughter lines, cutting and deboning lines, hygiene systems and logistics and packaging, the software solutions ensure constant, direct access to valuable process and product data.

For manufacturers, accurate traceability is key to guaranteeing the quality and food safety of premium meat products and selling them at the best price.

Real-time alarms built into the system keep manufacturers informed about expiry dates, reducing food loss. Potential quality problems are also easy to isolate, minimising the risk of recalls and related expense.

Recently, Frontmatec completed the implementation of a new automation system at a leading pork processing plant in Finland, one of the most advanced of its kind in the world. The entire cutting and deboning process is governed by highly automated recipe and order management, allowing planners and operators to control every aspect so each sales order is delivered precisely on spec.

Case by Frontmatec

RELIABLY SAFE MILK IN HALF A MINUTE


Photo: Foss

Any impurities are quickly discovered, assuring high food safety and quality

It takes just 30 seconds for a scanner developed in Denmark to detect whether raw milk has been wilfully adulterated. Developed by FOSS, the scanner is making a big difference in countries where swindlers may try to cheat their way to a better milk price.

India is one of the countries where the established dairy industry must be constantly alert to the risk of adulterated milk. This unfortunate trend puts consumers at risk and undermines dairy reputations.

FOSS worked with Arla Foods and other companies in the Danish food cluster to develop the revolutionary screening method, which can monitor milk quality right through the production chain. Called GoodProduct, the solution analyses the chemical composition of milk, including protein, fat, lactose and total solids. Any impurities are quickly discovered, assuring high food safety and quality.

In fact, GoodProduct is so fast that, if a contaminant is discovered, dairies now have time to call back the milk truck, rather than recalling milk already purchased by consumers.

Many Indian dairies have adopted the tool to safeguard the quality of the raw milk that enters their production lines. In one region, regular control has proven so effective that it has reduced milk adulteration by 98%.

Case by FOSS

CHAPTER 4

TECHNOLOGY WITH RESPECT FOR RESOURCES

SUSTAINABLE PRODUCTION IS WHEN EVERYTHING COUNTS

Photo: Food Nation

Efficient utilisation of resources is fundamental to sustainable food processes. Danish technology supports water and energy optimisation and biogas production from waste and side streams.

Wherever you look in the Danish food industry, targeted efforts are underway to improve energy and water efficiency and meet the stringent requirements of environmental legislation. New, innovative solutions are implemented on food processing lines to minimise energy consumption, facilitate water reuse and move towards a circular bioeconomy. Denmark has much to offer in this field.

Ongoing improvements in slaughterhouses, for instance, have reduced water consumption from 600 litres per pig in the 1980s to 150 litres today. New technological solutions such as pumps and advanced disinfection methods are making a difference in dairies and breweries. For many years now, Danish companies have led the ongoing development of membrane filtration. Apart from ensuring uniform and cost-effective production of high-quality cheese, membranes enable efficient water extraction for recycling.

Reducing groundwater consumption

A number of initiatives are exploring further opportunities to limit the use of groundwater in food production. One example is The Danish Partnership for Resource and Water-Efficient Industrial Food Production (DRIP), which aims to reduce groundwater consumption by between 15% and 30%.

To achieve this ambition, the public-private partnership is developing solutions so Danish food companies can produce more with less water. That includes reducing their reliance on the local water supply and increasing their use of purified recycled water – without compromising food safety and quality.

Water-efficient cleaning

No automated food processing line is complete without a fully integrated cleaning system. As this is an area that typically requires high volumes of water, a number of Danish companies have developed efficient cleaning technology to cut water use to a minimum without compromising food quality and safety. Water-free cleaning solutions with ozone are an alternative possibility.

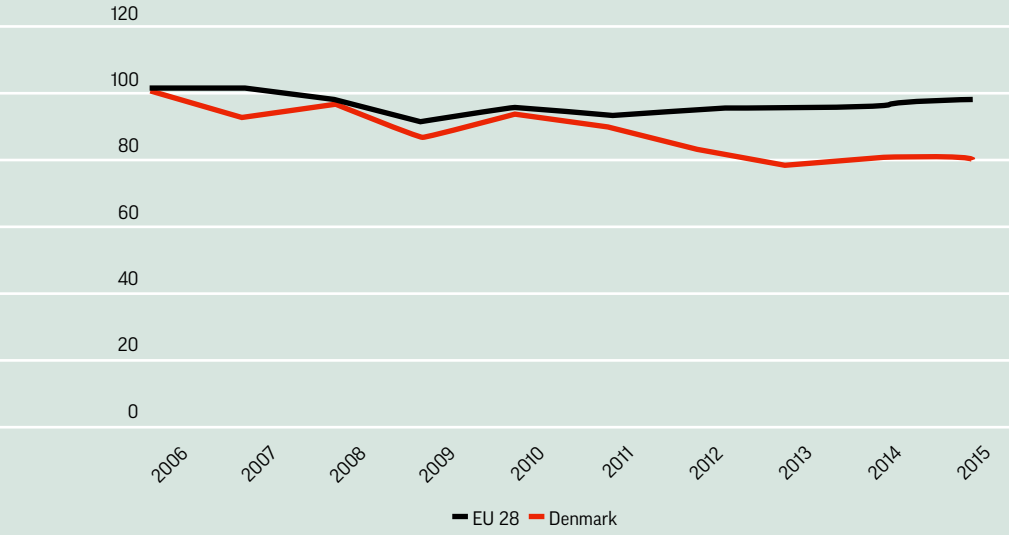
Reducing water consumption is an important focus in all food processing steps. Thanks to advances in technology and knowledge about water recirculation and reuse, it is now possible for food companies to comply with national regulations and meet their own ambitious sustainability targets.

Energy on the agenda

Measures to improve energy efficiency in food processing include high-tech doors for cooling and freezing systems and demand-driven ventilation systems that run only when required. Another option is to reclaim process heat produced during the day for heating cleaning water at night.

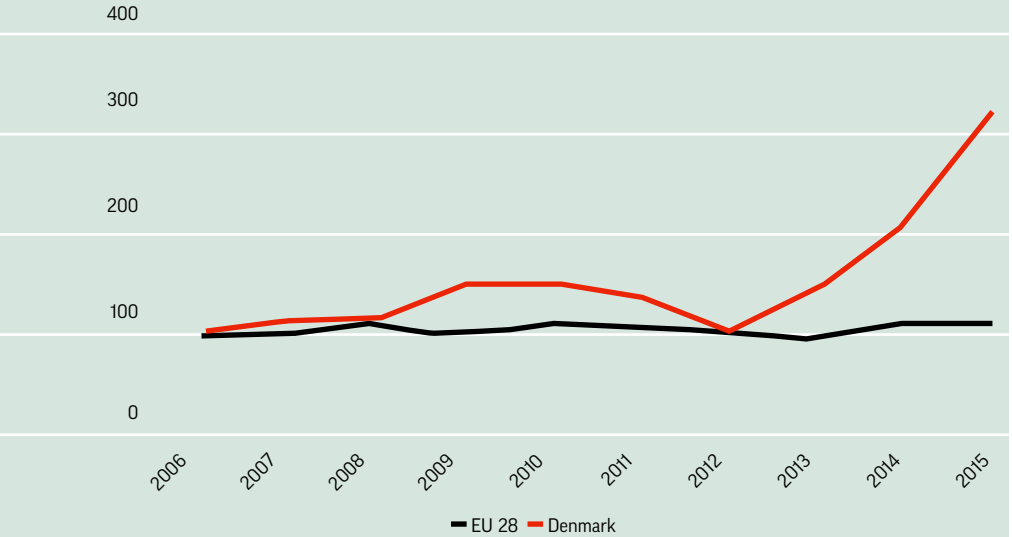
Innovative solutions are implemented on food processing lines to minimise energy consumption, facilitate water reuse and move towards a circular bioeconomy

Development in total energy consumption in the food processing industry in Denmark and EU-28 (2006=index 100)



Note: The food processing industry includes the tobacco industry
Source: Eurostat

Development in the total use of renewable energy in the food processing industry in Denmark and EU-28 (2006=index 100)



Note: The food processing industry includes the tobacco industry
Source: Eurostat

Opportunities to use renewable energy are also high on the agenda. Today, the food industry accounts for 30% of the energy consumed by Danish industry overall. Half of it is based on fossil fuels. For this reason, a number of food companies are already adapting their production processes to run on green electricity sources that can reduce their CO_2 emissions considerably.

Waste utilisation for biogas

In Denmark, the food industry increasingly relies on biogas as an alternative to natural gas and other fossil fuels. Food and slaughterhouse waste, raw material side streams, dead farm animals, manure and straw are the primary feedstock for biogas production. The degassed leftovers are then used as agricultural fertilisers – ensuring the full utilisation of all raw materials and the recycling of nutrients such as phosphorus, which is essential to plant growth.

Danish farmers began sending manure for biogas production in the mid-1980s. Today, as many as 100 farmers deliver manure to each biogas plant. Some large farmers have also invested in a biogas plant of their own. As a result, biogas now accounts for 20% of Danish gas consumption and makes a valuable contribution to the circular economy.

Over the years, Danish designers have optimised the design of biogas plants to maximise yield and minimise methane emissions. In the future, biogas will become an important energy source for transport and heavy industry processes.

RECYCLED WASTE IS FUEL FOR BIOGAS

Food waste and livestock manure are valuable raw materials at the Horsens Bioenergi co-digestion plant. Operated by engineering company Bigadan, the plant uses this feedstock to produce 28 million cubic metres of biogas a year – enough to meet the energy needs of 4,000 Danish households.

Local farmers and food producers such as Danish Crown have sent their waste and side streams to the biogas plant since 2014. Restaurants, canteens and others in the catering sector rely on waste management company Daka ReFood to collect their food waste and deliver it to the plant for recycling.

Upgrade to natural gas

Bigadan has built a reputation on its skilful ability to engineer and run biogas plants adapted to specific feedstock. This expertise has also driven the recent increase in capacity for upgrading biogas to sustainable natural gas, supporting the transition away from fossil fuels..

All feedstock is sterilised on arrival at the plant to remove potential pathogens and weed seeds. Around 100 farmers then use the degassed leftovers as a fertiliser that returns nutrients to the soil.

Photo: Bigadan

Surplus heat from the biogas plant and wastewater from local industry are used for the pulping process at neighbouring Daka ReFood.

The entire operation adds up to a great example of a circular bioeconomy, where renewable raw materials create maximum sustainable value.

Case by Bigadan

> This is a great example of a circular bioeconomy, where renewable raw materials create maximum sustainable value

SUSTAINABLE CLEANING IS FAST AND HYGIENIC

It can be difficult for food manufacturers to reduce their water consumption without compromising the high hygiene and food safety standards required by authorities and consumers. When operators wash processing equipment by hand, it is also difficult to ensure standards are met.

> The system cuts cleaning time to just six minutes and water consumption to 16 litres

Photo: Jeros

The Danish company JEROS is making a difference for food manufacturers all over the world. Based on more than 55 years of experience, their cleaning solutions ensure unparalleled levels of hygiene with less water usage – enabling manufacturers to improve the sustainability of their production.

One of their solutions, the JEROS ACE is the most flexible and efficient cleaning system for multi-head weigher components and other scale parts in food production.

Using a traditional manual process, it typically takes operators an hour to clean 32 multi-head weigher components and 730 litres of water. The JEROS ACE system cuts cleaning time to just six minutes and water consumption to 16 litres.

A rinse temperature of 85°C also ensures all components are thoroughly disinfected and hygienic – ready for the next product batch.

Trusted around the world

With a JEROS system, food producers can look forward to more environmentally friendly production, uniform food safety and lower operating costs. Large food conglomerates like Pepsico and Nestlé and the Danish dairy giant Arla Foods have all implemented JEROS solutions in their production.

Case by Jeros

CLEAN CHICKEN FEET WITH HALF THE WATER

Danish meat processor HKScan has found that saving water and energy is sometimes surprisingly easy. In its poultry abattoir business, the company has cut water consumption by 100 cubic metres a day on its chicken feet line, simply by reversing the water flow. A lower water temperature has also brought daily energy savings.

Chicken feet are big business. But, before the feet can be packed and exported, they are exposed to a lot of water, both to soften them so the skin can be removed and for cooling.

> The new approach has cut daily water usage on the chicken feet line by 50%

In the past, clean water was used for every processing step and then sent to the factory's wastewater treatment facility. Now, by pumping counter-clockwise, the water is moved from the clean cooling process to the earlier dirty processes.

The new approach has cut daily water usage on the chicken feet line by 50%, equivalent to 7% of the factory's overall water consumption.


Photo HKScan

Furthermore, in the skin removal process, HKScan found that they could lower the water temperature from 55°C to 35°C at no expense to hygiene or product quality, cutting energy costs by EUR 100 a day.

For HKScan, their efficiency project has been a real eye-opener – and an inspiration for many other improvements, which are now underway.

Case by HKScan

CHAPTER 5

VISIONARY TOOLS FOR TRANSFORMING FOOD

MEETING CHALLENGES THROUGH CONTINUOUS INNOVATION

Photo: Danish Technological Institute

Pioneering technology is creating new opportunities to adapt and respond to global food supply challenges.

Denmark has long been a driver of innovative technology, ranking sixth among high-income countries in the Global Innovation Index 2020. As the agrifood sector faces up to the challenges of climate change, a growing world population and shifts in consumer behaviour, Danish innovation will continue to be a reliable choice in the future. Our collaborative culture provides a solid foundation for ambitious development programmes focused on optimising the efficiency and sustainability of food production.

Today, the food and agriculture sector is undergoing a major transformation. Many farmers and food producers are already experiencing how smart, digital technology can improve production yields, take food safety and quality to new heights and minimise waste – all key parameters in the United Nation's Sustainable Development Goals.

In Denmark, we have a finger on the pulse of the digital transition and welcome collaborative projects that aim to maximise the potential of artificial intelligence, Internet of Things and similar technological opportunities. The arrival of 5G is an important part of this movement, paving the way to more flexible production using mobile machines that operate through wireless internet connections. It may not be long before operators will be able to rely on augmented and virtual reality to carry out machine maintenance without having to be physically present on site.

The rise of urban farming

Rising urbanisation and the need to reduce CO_2 emissions related to logistics and transport are driving a trend towards local crop cultivation in areas previously not associated with food production. Sunset Boulevard, for example, is the first fast-food restaurant chain to use Danish hydroponic technology for lettuce production all year round.

Suitable for containers, high-rise office and apartment buildings and many other indoor environments, vertical farming can be expected to inspire many more commercial ventures in the years ahead. Danish technology companies, horticultural specialists and research institutes continue to develop new, innovative solutions in this field.

3D printing and alternative proteins

Danish food specialists are also exploring the possibilities to improve health and nutrition through 3D printing. One major focus area is to develop foods for people with swallowing difficulties or other conditions, including the special needs of allergy sufferers. Based on the work of a cross-sector project involving Danish research institutes and ingredient companies, the first 3D printed foods are approaching market launch.

In rural Denmark, on the other hand, farmers have good opportunities to become high-tech producers of alternative proteins that supplement proteins from meat and dairy products. This includes establishing green biorefineries to extract proteins from grass and the development of innovative technology for the production of insect larvae.

Through a continuing commitment to make the best of limited resources, Danish technology is tackling the challenges that face the global food supply. This forward-looking innovation is driving food and agriculture towards the UN Sustainable Development Goals.

There is an accelerating need for innovative technology that can increase food production and enable more sustainable practices

BIOSENSOR TO REDUCE ROUTINE ANTIBIOTIC USE


Photo: Danish veternary and Food Administartion

> Using this detection tool, farmers can quickly determine whether diarrhoea-provoking bacteria are to blame when piglets become sick

Just-weaned piglets have an immature immune system that leaves them highly susceptible to diarrhoea. To treat and prevent the problem, farmers traditionally turn to antibiotics – an expensive practice that may not always be necessary.

Part of the explanation for this routine antibiotic use is that farmers do not have time to follow the standard procedure for diagnosing disease, which is to send samples to a laboratory for analysis. Such a delay can lead to a higher mortality rate with associated losses in production.

Fast E.coli detection

The Technical University of Denmark (DTU) is developing a biosensor to overcome this challenge. Based on nanotechnology, the sensor is designed to capture so-called virulence factors from E. coli bacteria, which kill more than a million piglets a year in Denmark alone.

Using this detection tool, farmers can quickly determine whether diarrhoea-provoking bacteria are to blame when piglets become sick.

The ultimate goal is to reduce unnecessary antibiotic use, which contributes to the development of multi-resistant bacteria. At the same time, animal welfare and farm profits are both improved.

DTU is currently working with pig farmers to evaluate how the biosensor can be used to greatest benefit.

Case by Technical University of Denmark

MICROALGAE - THE NEW FEED PROTEIN

Microalgae has high potential as an alternative protein source for animal feed. Requiring up to ten times less space for cultivation than conventional feed proteins, it grows fast and efficiently in areas typically not suited to agricultural production.

A Danish consortium of research institutions and businesses is taking the sustainability perspective to the next level. Through the development project ReMAPP, their ambition is to produce microalgae with CO_2 and nutrients from the side streams of biogas production.

Danish Technological Institute has developed tube-shaped bags for the first test production at the NGF Nature Energy biogas plant. Producing 13 million cubic metres of biogas annually, the plant has the capacity to feed the production of 4,700 tonnes of microalgae a year.

The ReMAPP project, that is supported by the Danish Innovation Fund, is focusing on the whole microalgae supply chain, from cultivation and harvest to processing into a safe and nutritious protein for animal feed. A Danish farm with organic vegetable and poultry production and own biogas plant will test the concept in early 2022.

Case by Danish Technological Institute

Photo: Danish Technological Institute

The ambition is to produce microalgae with CO_2 and nutrients from the side streams of biogas production

CHAPTER 6

A GUIDING LIGHT TO GLOBAL SOLUTIONS

THE GROWING NEED FOR SMART TECHNOLOGY

Photo: Next Food

The UN Sustainable Development Goals are a guide to overcoming the challenges to the world food supply. Innovative technology from Denmark is part of the solution. Contact Food Nation to find out more.

Photo: Food Nation

> By working together and thinking ahead, the goal is to speed up progress and bring new technology faster to market

The food and agriculture sector will need many more smart solutions to meet the world's growing demand for safe and nutritious food. In the years ahead, we will face an unrelenting need for more innovative technology to support precision farming, efficient food production and maximum use of raw materials. We will need to produce more food on less land and develop new sources of sustainable protein.

In Denmark, research institutes and businesses continue to innovate high-tech solutions across the value chain to meet these needs. By working together and thinking ahead, the goal is to speed up progress and bring new technology faster to market. One of the purposes of this white paper is to showcase how this is happening.

Since the United Nations launched the Sustainable Development Goals as a call to action in 2015, the Danish government, businesses and research institutions have adopted them as a guide to next-step innovation. New technology start-ups have appeared to support food and agricultural companies in their digital transition. Far-sighted development projects have been initiated to explore previously unexplored possibilities to strengthen the food value chain.

Danish technology developers and cluster organisations also participate in international collaboration projects. That includes taking part in EU-funded programmes to support the digitalisation of the European agrifood industry and, beyond that, the global need for green change.

Food Nation

Food Nation is a non-profit partnership established by the Danish government and leading private organisations and companies. It is your gateway to information about the Danish food cluster and knowhow that can accelerate the growth of international businesses through better solutions, innovative products and trusting cooperation.

The Danish food cluster encompasses everything from primary production in agriculture and the fishing industry to the food products consumers buy in stores. Companies, universities, research institutes, local and national authorities and other private and public organisations belong to the extensive, collaborative network. Together, they work hand-in-hand with international partners to maintain and improve food quality and safety along the value chain.

Take an interactive tour

Food Nation's visitor centres welcome international delegations, providing them with an introduction to Danish capabilities within food. An interactive installation gives visitors an up-to-date overview of the food value chain based on their individual interests. It is the ideal starting point before visiting Danish food producers and production facilities.

Food Nation is a great place to start learning about how Denmark can support sustainable development through collaboration. Find out more about our services, the Danish food arena and arranging a visit to the Food Nation visitor centres at foodnationdenmark.com.

INGREDIENT INDUSTRY

Producers of enzymes, cultures and other ingredients

PRIMARY PRODUCTION

Agriculture, fishing & horticulture

PROCESSING INDUSTRY

Producers of food, beverages & animal feed

The Danish food cluster

Denmark is home to countless large, medium and small companies, research institutes and other organisations that make the country a European hotspot for innovative food products, services and technology.

RESEARCH & INNOVATION

Research, education & counselling institutions

INNOVATIVE TECHNOLOGY

Producers of machines, technology & equipment

GASTRONOMY & THE CONSUMER

Retail, consumers, restaurant, authorities, tourism & other related industries

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