

PROFILE 2021

AU ENGINEERING

RESEARCH
COLLABORATION
EDUCATION

BUILDING BRIDGES

"One cannot alone accomplish anything truly great. Results are always achieved in collaboration with others."

Meet legendary bridge building pioneer Klaus H. Ostenfeld, who is new honorary professor at Aarhus University

GREEN CONSTRUCTION SITES

New partnership will focus on the green transition of construction sites – and there's a lot to be gained.

A DIGITAL TWINS DREAM TEAM

Meet the figurehead of the Aarhus University investment in the hyped technology of tomorrow.

GREEN ENERGY TRANSITION

To reach climate-neutrality by 2050 we need solar energy. Lots of it.



AARHUS
UNIVERSITY
AU ENGINEERING





DAILY MANAGEMENT 2021

Lars Ditlev Mørck Ottosen, head of the Department of Biological and Chemical Engineering

Mikael Bergholz Knudsen, head of the Department of Electrical and Computer Engineering

Anders Brandt, head of the Department of Mechanical and Production Engineering

Mikkel K. Kragh, head of the Department of Civil and Architectural Engineering

Andy Drysdale, team leader, Business Relations and Partnerships

Contact: contact@auengineering.au.dk

engineering.au.dk/profile



Danish upper-secondary school students can try their hand at scientific research and perhaps even help in a discovery that could have a major impact on millions of people all over the world. A grant from the Novo Nordisk Foundation has given Aarhus University the opportunity to let school students take part in important research to find new antibiotics. Read online at engineering.au.dk/collaboration

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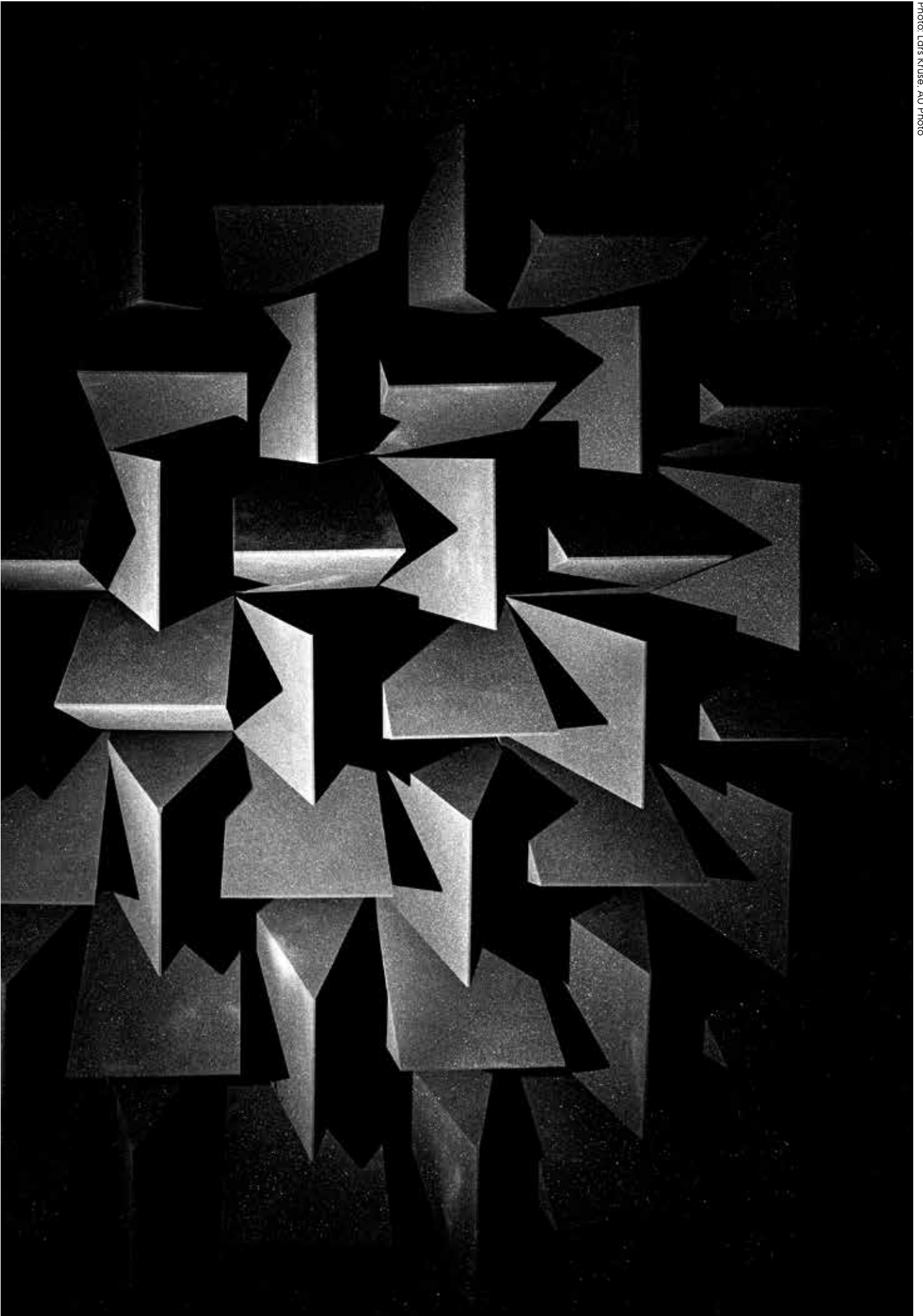
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Audio Lab at the Department of Electrical and Computer Engineering, Aarhus University.



Great ambitions for the future

Ten years ago, Aarhus University had no engineering research environment. Today, our research compares to the best in the world. We have steady increase in student enrollment, and revenues and number of publications are growing fast.

This is a remarkable development that we can be very proud of, and it is an excellent foundation for our four new engineering departments. The knowledge we generate at the university creates value in society. Many of the technologies that characterise the world today are commercial offshoots of university research, and therefore business collaboration is high on the agenda in our efforts to strengthen engineering at Aarhus University.

Our goal is to help solve major societal challenges within climate, the environment, health, food and digitalisation, but we must also ensure that the knowledge we generate reaches out effectively to our surroundings and becomes a lever to develop the business community.

The articles in this magazine are very good examples of this.

Companies today are facing a reality in which their competitiveness is increasingly dependent on their ability to generate and utilise new knowledge. Companies that work with universities have higher growth and productivity than comparable companies. As a university, we want to integrate the issues and technology challenges currently facing business and industry into our educational and research activities. This is an important interplay and an excellent starting point for innovation.

Find your own inspiration in the collaborations we have highlighted here.

Happy reading!

Eskild Holm Nielsen,
Dean of the Faculty of Technical Sciences,
Aarhus University



WEB EXCLUSIVE

The potential of autonomous solutions for offshore operations in the maritime sector is huge. The Danish drone company Upteko is collaborating with researchers from Aarhus University to develop next-gen drone tech and AI for everything from rescue operations to 3D scans and inspections of entire ships.

"Today, everything is done manually. From inspections of damage or cargoes, to keeping an eye on icebergs and pirates in perilous waters. We'd like to change this by using modern drone technology adapted to the maritime sector."

Mads Jørgensen, director at Upteko ●

Read online





Photo: AU Photo

The new research and demonstration laboratory, the AU Digital Transformation Lab, is located at Innovest in Ringkøbing-Skjern Municipality.

NEW KNOWLEDGE, NEW INNOVATIONS, NEW RELATIONS

DIGITAL TRANSFORMATION LAB SKJERN

The large-scale industrial and academic collaboration project between Ringkøbing-Skjern Municipality and Aarhus University is a great opportunity for companies to tap into the industrial and digital transformation.

Backed by a DKK 16 million (EUR 2.2 million) investment, Ringkøbing-Skjern Municipality and its Knowledge Committee together with local companies, the Ringkøbing-Skjern Business Council and Aarhus University have opened a new research and demonstration laboratory, the AU Digital Transformation Lab (DTL-Skjern), located at Innovest in Skjern.

The lab is to showcase the future of industry and form the basis for developing product prototypes with increased digitalisation, new materials and production technologies in a joint effort to ensure that local companies are at the forefront of the digital transformation.

“Our job is to strengthen relationships and ensure a closer proximity between the university and the local business community. To allow for much better knowledge sharing, providing societal growth and input for research into future solutions and to become the link between research, education and businesses,” says Jakob Lemming, manager for the new lab, which will be officially inaugurated in summer 2021.

Starting up digital projects

DTL-Skjern is established jointly between the Ringkøbing-Skjern Business Council and the Department of Electrical and Computer Engineering at Aarhus University. The laboratory is key in exchanging research-based knowledge from the university and practice-based knowledge from companies.

“It’s an exciting task that I approach with great humility,” says Jakob Lemming and continues:

“The first step will be to get in touch with the local business community and the team at the university. And I believe, that we can begin starting up digital projects in the municipality fairly quickly, for the benefit of the participating companies.”

DTL-Skjern is linked to the AU Centre for Digitalisation, Big Data and Data Analytics (DIGIT), and there are plans to establish parallel laboratories in other municipalities in the Central Denmark Region. The individual laboratories will be linked together through a central hub at AU.

In Ringkøbing-Skjern, focus will be on digital twin technology, which makes it possi-

ble to make a digital copy of a product or a production process, which you can then develop and run tests on.

Growth and innovation

The lab is ‘a huge opportunity’ for for the municipality’s manufacturing companies, according to Mayor Hans Østergaard:

“Many of our manufacturing companies are already among the leading innovative players in their field, but the specialist knowledge that Aarhus University contributes to this project can help to secure the basis for growth, development and innovation and thus take our companies to new heights.”

When officially opened, the lab will be open for visits from companies and partners, and there will be activities for school classes and youth programmes several times a year. In addition, PhD students, postdocs and other researchers will regularly communicate the results of their research via lectures. Until the opening, Jakob will walk the corridors of the Ringkøbing-Skjern Business Council at Innovest.

The project will run over a three-and-a-half-year period. After the grant period, the goal is for the lab to be self-financed. Funding will then come from companies and research and development projects.



Contact:

Jakob Lemming
Lab Manager, DTL-Skjern
Department of Electrical and
Computer Engineering

jle@au.dk

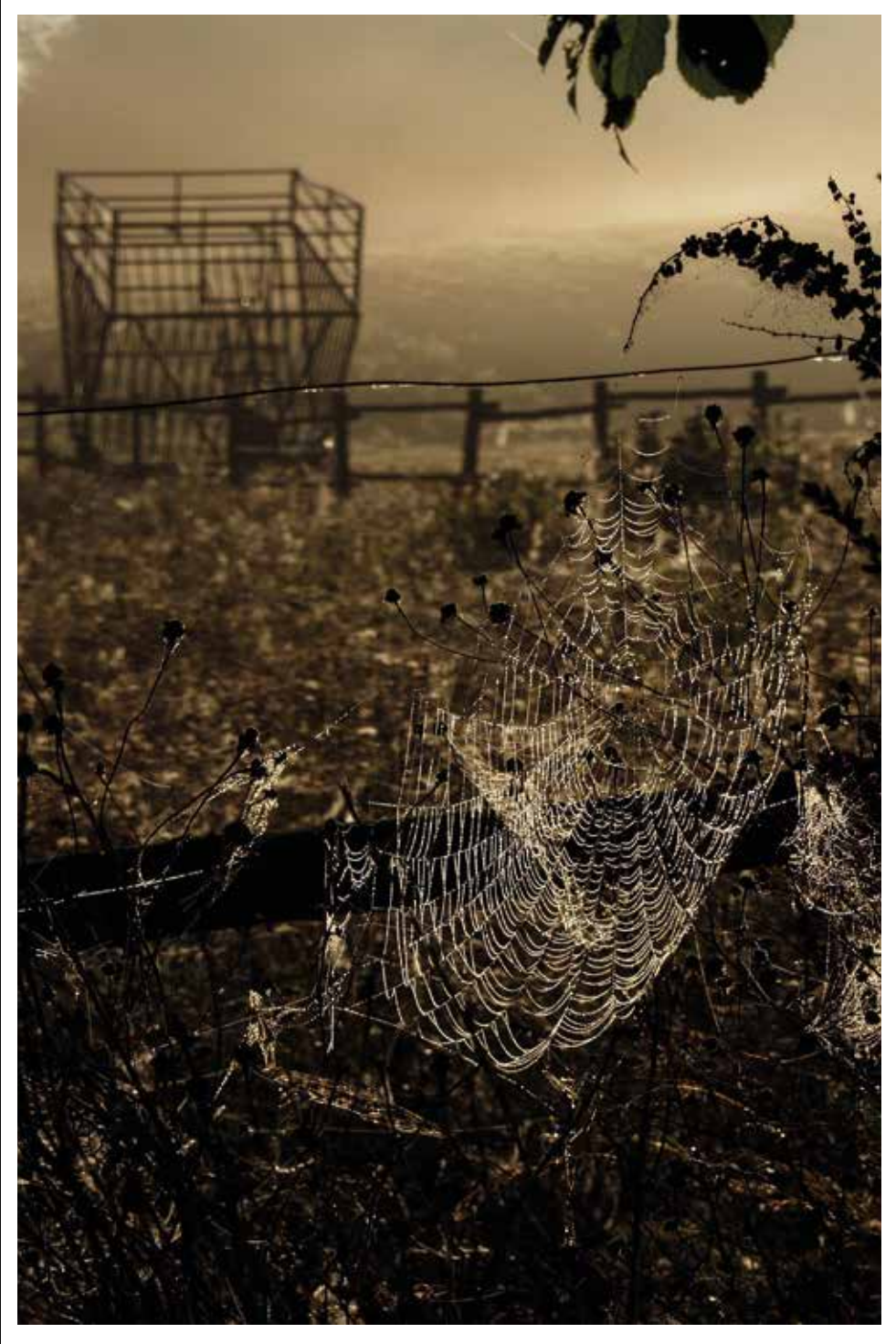


Photo: Colourbox

ROOM FOR MORE NATURE?

Agriculture is facing a paradigm shift. Its future is not just about autonomous robots, smart sensors, artificial intelligence or other such high tech that might ease the life of farmers.

For centuries, we have cultivated the land in a way that causes environmental issues. New technology now allows us to clear a completely different path for farming. A path that can initiate a pervasive green transformation of all of society. It's all down to something as fundamental as what we grow on fields and what we put in our mouths.



The meat industry is one of the most important branches of the Danish agricultural sector. Most of the cultivated land in Denmark is used to produce animal feed. But what if we could get a lot more meat out of a much smaller area? And what if this was not the only thing we could get out of the crops?

Eight kilometres east of Viborg rests the small village of Foulum. The AU Foulum Research Centre is located just south of the village. It is one large, cohesive laboratory ecosystem in which technology and engineering sciences merge with the latest livestock and agricultural research. The goal is a green revolution. And it's just around the corner.

AU Foulum houses a total of 120,000 square metres of laboratories used by researchers from the university's departments of Animal Science, Agroecology, and Biological and Chemical Engineering, as well as research groups from the Center for Quantitative Genetics and Genomics, and DCA, the Danish Centre for Food and Agriculture.

The focal point for engineering researchers is a green transition of society's current linear fossil economy to a completely new type of economy: A sustainable system based on the premise that we only have the world's biological resources on loan, and therefore they have to be part of a circular system with minimal depletion.

In short: a circular bioeconomy.

"Our entire society is currently chiefly based on fossil raw materials and energy sources. We aren't just talking about energy for heating, electricity for light and fuel for transport; we're also talking about how

our entire industry and production focuses on predominantly fossil raw materials. If we are to make a difference in climate change and global pollution of nature and the environment, we have to rethink the entire infrastructure," says senior researcher Uffe Jørgensen, who is head of the Aarhus University Centre for Circular Bioeconomy, CBIO.

What Uffe is talking about basically comes down to what crops we grow on our fields.

For thousands of years, Danish farmers have refined the agricultural sector towards so-called yellow crops. These are annual crops such as corn and rapeseed, which are green in the spring, yellow in the summer and harvested in late summer so that the fields are brown in the autumn.

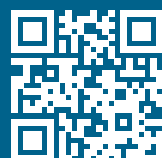
"Seen from a circular and resource-efficient perspective, this is absolutely ridiculous. We waste up to half of our growing season with no photosynthesis, and what's worse is that these cultivation concepts exacerbate the sector's serious environmental problems, including nitrate leaching, pesticides and reduced carbon content in the soil. By using green, perennial crops, we can solve many of agriculture's environmental challenges," says Uffe Jørgensen.

Going from a fossil based economy to a circular and biobased economy holds significant societal and industrial potentials.

In 2017, Aarhus University established its Centre for Circular Bioeconomy (CBIO) to carry out research and develop bio-economy production systems and recirculation concepts.

Read on at cbio.au.dk or use the link below.

Read online





By allowing green crops in fields, researchers are designing an agricultural landscape based on a natural-sciences principle of the best use of resources. In the photo: Senior researcher Uffe Jørgensen.

By allowing evergreen grass and clover to grow in fields, we can start designing an agricultural landscape based on a natural-sciences principle of the best use of resources. In a circular mindset and from a climate perspective, it is about having as long a growth season and as many green plants as possible. This creates photosynthesis, and it binds carbon from the atmosphere in the biomass.

“Photosynthesis is the only significant negative greenhouse gas emission we have, and it has a major impact on the carbon

balance. That’s why we have to get as much of it as possible. And from there we can begin to solve the climate challenge technologically. More green crops will be a revolution in agricultural production, because they are clearly the most optimal for the climate, the environment and nature, but up to now there has been no market for green crops other than as cattle fodder,” the senior researchers says.

The vast majority of the yellow crops grown today are used for animal feed, and only a little goes to other uses such



Photo: Jørgen Weber, AU Photo

The large research facility of AU Foulum – a stone's throw away from the tiny village of the same name.

as human consumption. Residues such as straw are used for feed, bedding and fuel and biogas production.

The perspectives for green crops are somewhat different.

Firstly, green crops can produce far more biomass per hectare of farmland than yellow crops. They are also far more resilient and bind more carbon and nitrogen.

The green biomass can supply energy in biogas plants, and via biorefining can be converted into protein powders, chemicals, bioplastics, building materials, green fuels, clothing textiles, pharmaceutical products and much more.

Coupled with further bio- and chemical engineering processes, such as electrolysis, we get into the whole area of Power-to-X and the electrification of society. This means that green biomass from agri-

culture could be a major player in a wide range of industries that today are based almost exclusively on fossil raw materials.

"The biodiversity crisis, pollution of nature and the environment and the climate crisis are massive issues that can be solved by the same approach, i.e. far better and more efficient production of biomass and a multitude of technologies that can convert biomass into the products that society is looking for now and in the future. It entails a total and complete reorganisation of the way we produce food, and it has far-reaching consequences for carbon-based manufacturing industries," says Professor Lars DM Ottosen, head of the Department of Biological and Chemical Engineering.

He continues:

"We've come to a point when we have to rethink everything. Right now agriculture has a chance to take the lead and become the driving force behind the en-



Contact:

Uffe Jørgensen
Senior Researcher
Department of Agroecology

uffe.jorgensen@agro.au.dk

“

The biodiversity crisis, pollution of nature and the environment and the climate crisis are massive issues that can all be solved by the same approach. It entails a total and complete reorganisation of the way we create food, and it has far-reaching consequences for carbon-based manufacturing industries.”

Professor Lars DM Ottosen



Contact:

Lars DM Ottosen
Professor, Head of Department
Department of Biological and
Chemical Engineering

ldmo@bce.au.dk

tire green transition. Clearly, this requires a great deal of development, primarily relating to the total reorganisation of our food production, but if we do so the possibilities are colossal.”

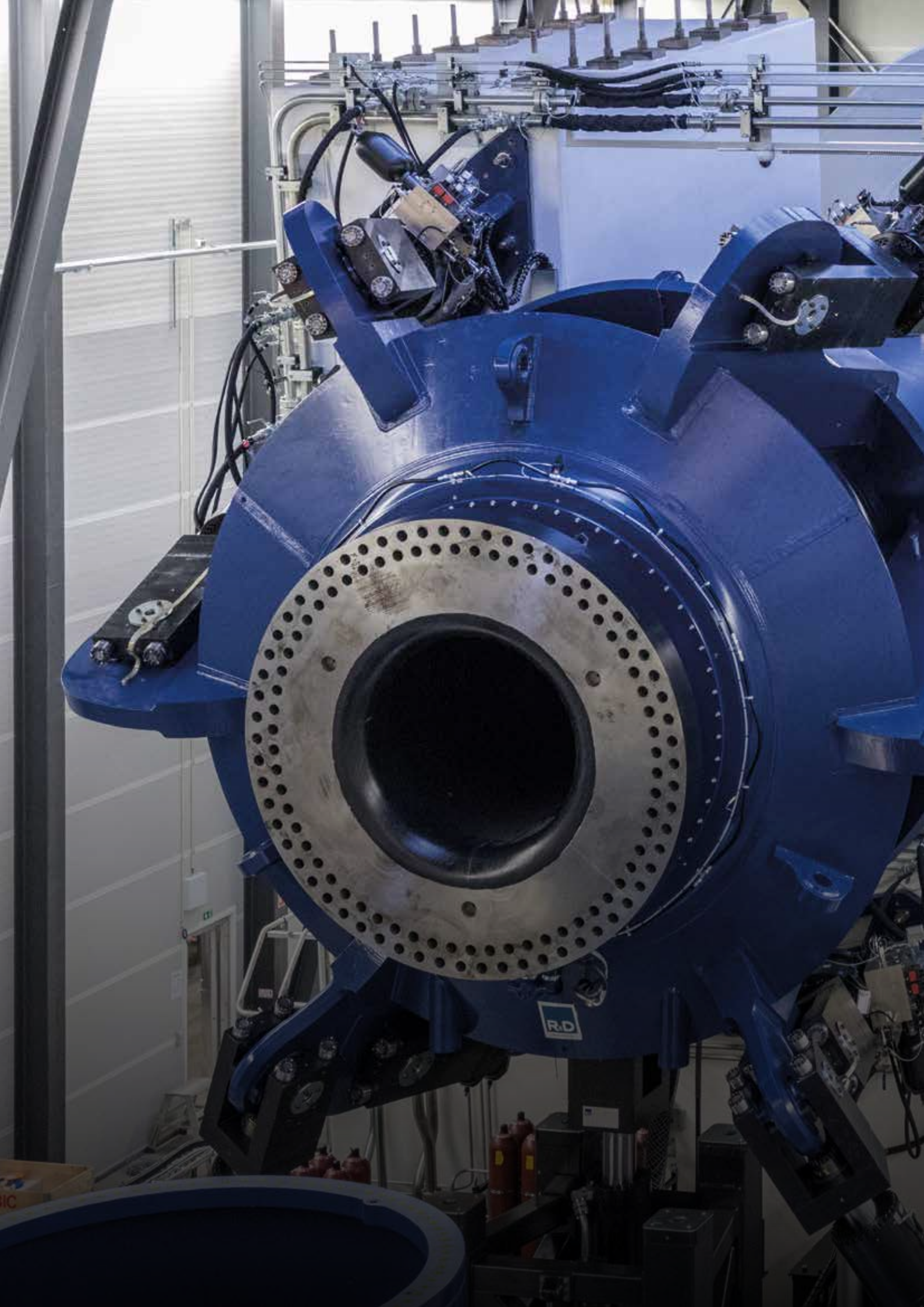
Lars DM Ottosen believes that the main difference in the agriculture of the future will be far less livestock. Instead, meat and other animal products will be replaced by cell-based technologies.

“Generally, nothing can measure up to a cell-based approach to food production. The technology doesn’t pollute, and there are no losses. We can produce the same amount of food with far less than half of the feed input demanded by livestock, and coupled with green crops, this will mean that you can produce far more food on much less farmland. This opens up for more nature in many of the areas that are currently used for agriculture, and with far more environmentally friendly biomass

production, we’ll have good opportunities to improve biodiversity,” he says.

Research at Foulum has already come a long way. The first farm site for biorefining grass was taken into use in 2020 by Kristian Lundgaard-Karlshøj, a farmer at Ausumgaard near Struer, and more and more farmers are looking at the possibilities in a new Danish export enterprise that literally is green.

“We have some important goals to reach by 2030 and more ambitious goals for 2050, and we will have to work with companies and enterprising farmers to reach these. The possibilities at Foulum are unique, and the collaboration between engineering science, agroecology and animal research opens up for many exciting new areas to take us even further with these technologies. An exciting future lies ahead for Danish agriculture,” says Senior Researcher Uffe Jørgensen. ●



WEB EXCLUSIVE

The wind industry's ability to innovate depends to a high degree on the technological possibilities for testing ever-larger nacelles.

In collaboration with Aarhus University, the engineering company R&D Test Systems are developing an unparalleled test bench for the next generation of giant wind turbines.

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FOUR NEW ENGINEERING DEPARTMENTS

AARHUS UNIVERSITY HAS IMPLEMENTED AN ORGANISATIONAL CHANGE TO OPEN FOUR NEW ENGINEERING DEPARTMENTS. THIS IS PART OF THE WORK TO ENHANCE RESEARCH WITHIN TECHNICAL SCIENCE.

Department of Civil and Architectural Engineering

Keywords: Building and construction, building design, building physics, building production, socio-technological design, construction materials, geotechnical engineering, building mechanics, energy and indoor climate, infrastructure, the environment and climate adaptation.

Department of Biological and Chemical Engineering

Keywords: Industrial biotechnology, food technology, environmental technology, materials and polymer chemistry, medical biotechnology, electrochemical technology and process technology.

Department of Electrical and Computer Engineering

Keywords: Communication and networks, control and automation, photonics, signal processing, software and IT systems, robot technology, medical technology, health technology, electrical energy technology, and acoustics and sound technology.

Department of Mechanical and Production Engineering

Keywords: Energy systems, thermodynamics, fluid mechanics and heat transfer, materials technology, robot technology and machine dynamics and construction, materials technology, mechatronics.

Go online



A portrait of Claus Melvad, a man with a beard and glasses, wearing a light blue button-down shirt. He is sitting at a table with his hands clasped in front of him. The background is dark.

“It’s kept me awake at night”

Claus Melvad is the man behind perhaps the world’s most comprehensive and innovative portfolio of climate research technology. Working closely with students and climate researchers from Danish universities, Claus has managed to fill in some essential pieces of the jigsaw puzzle of global warming. The seriousness of the problem has been of great personal importance to him.



A polystyrene box and a broomstick

It all started in 2014.

Claus Melvad had come to Aarhus University after a long career in industry. He had a dream of teaching and immersing himself more in what most would consider an unlikely interest – namely exploring underwater.

He managed to instil a fascination for mechatronics in his students on his very first semester, and shortly afterwards they signed up for an international university competition to design underwater robots.

Claus' team returned home in triumph, and with a lot of media coverage. He was then contacted by research colleagues at the Arctic Research Centre at Aarhus University.

The climate researchers wanted to monitor the development of the algae that grow under the sea ice in our northern hemisphere, and they had an idea that Claus Melvad might be able to help their research.

"I think that was when I realised that I could make a significant difference with my specialist knowledge as an engineer, and for me it has always been a huge privilege to work with talented researchers. Ice algae are important because they constitute the vital primary production in the Arctic, but at that time we lacked the technology to move around under the ice and take good measurements. Norwegian researchers had published a solution using a polystyrene box to pack their sensor equipment so that it could float. The polystyrene box was then pushed around under the ice with a broom, and they extended the broomstick with another broomstick and duct tape, so they could expand the range of their underwater reach. It was all very low-tech, and clearly

there were limitations," says Claus Melvad.

He therefore engaged a group of students to develop an underwater robot that not only could measure algae growth under the ice, but also had an innovative, light-based positioning system.

Feeling of powerlessness

Claus Melvad's spectacular career in engineering took off here. He worked more closely with climate researchers. He was allowed into their engine room and he decided to gain scientific insight into their challenges. This led to several ideas and new technology-development projects, and Claus engaged his students in the work.

"I was moved at a very personal level. I've been concerned about how serious the climate change problems are for some time. It's often kept me awake at night. I think that I've channelled the powerlessness I felt into a very strong commitment to my work. I see it as my task to develop technology that can enable us to understand and limit the consequences of global warming. Of course, this has also affected the many groups of talented students who've worked on my projects. They've been driven by strong motivation that has also resulted in remarkably good study performances," he says.

Together with his students, Claus Melvad has managed to make a clear mark on the results of international climate research in recent years.

They have helped researchers carry out several dangerous, difficult and time-consuming tasks on polar expeditions. They have invented drones that can drill cores out of icebergs, autonomous



Contact:

Claus Melvad
Professor (Docent)
Department of Mechanical and
Production Engineering

cme@mpe.au.dk

BIO

Name: Claus Melvad**Title:** Professor (Docent)**Expertise:** Mechatronics, underwater robots, drones and autonomous vehicles on land and water**Age:** 37**Residence:** Horsens

boats that can measure the salt content of the sea, underwater robots that can take deep-water 3D scans of icebergs, and autonomous buoys that can profile freshwater additions from glaciers. Just to mention but a few projects.

“If we really want to understand the consequences of global warming, we need to know what’s going on in the Arctic Ocean. We know that temperatures are rising. We know that the ice is melting. But we don’t know much about what happens when freshwater mixes with seawater. The researchers have a blind spot, and this is a major problem, because even small fluctuations in the salt balance can affect the fine mechanisms that regulate maritime currents and thus our entire ecosystem and the global climate. I feel a huge responsibility to help research with what I’m actually quite good at,” says Claus Melvad.

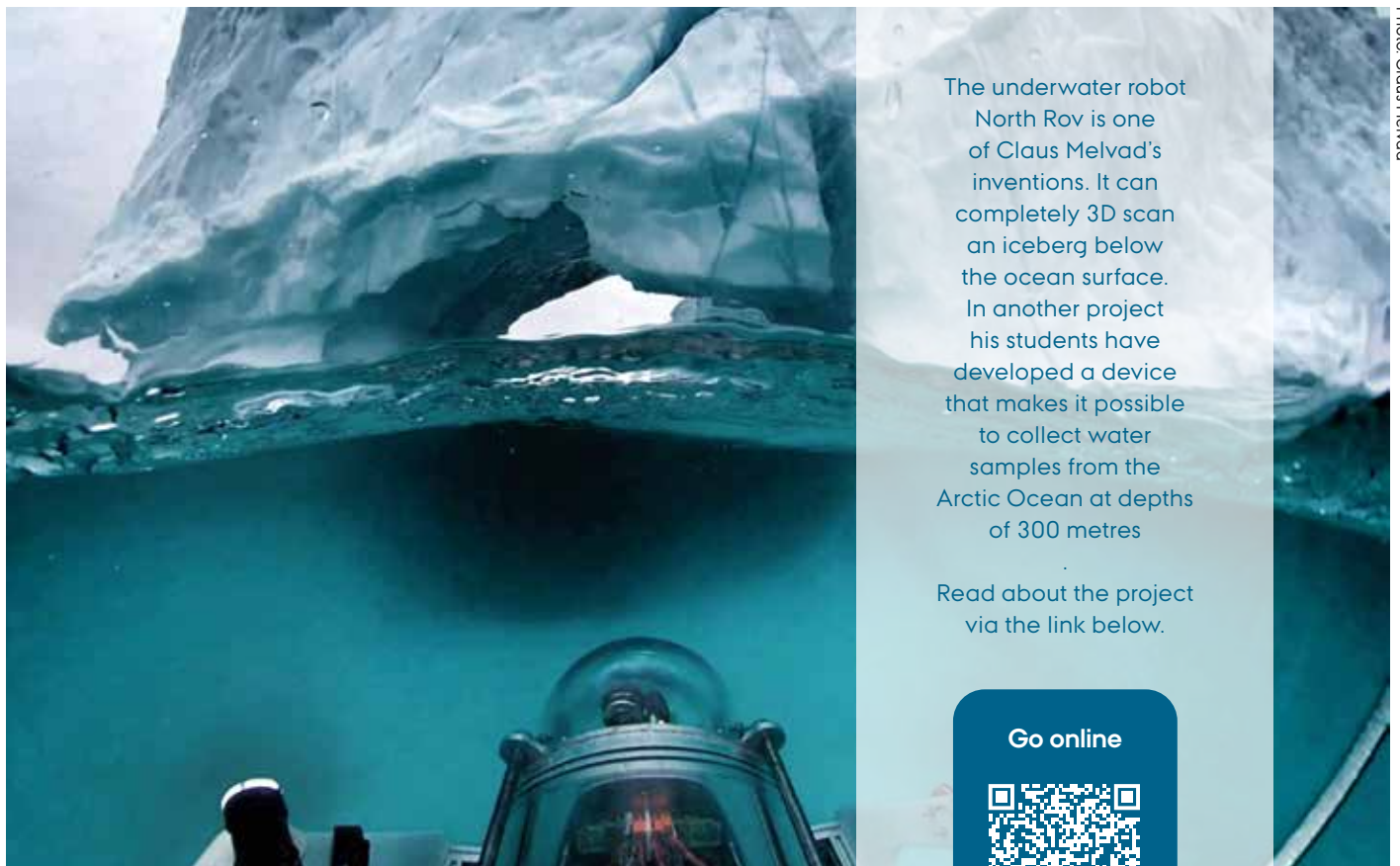
Recipe for innovation

Claus Melvad is good at getting ideas. He is good at solving problems, and he can spot possibilities at the interface between electronics, software and mechanics with awesome precision. He is also ambitious on his own behalf, but perhaps especially for his students.

“They’re working on something that’s meaningful for them and important in a wider perspective. Their results will be published openly so that others can continue to build on them. I’d like to teach them to think creatively, aim high, have the courage to fail and push the limits of what is possible. This is perhaps the most important recipe for innovation,” he says.

During his employment at Aarhus University, Claus Melvad has spent a great deal of his waking hours developing technology to support climate researchers in their work. His students have together spent more than 120,000 hours at a market value of more than DKK 42 million on the various projects. Moreover, there have been a number of successful polar expeditions.

“You stop counting in hours. This is something close to my heart. Global carbon emissions are moving in the wrong direction, and I see the consequences coming at an unprecedented pace. Explaining why things are moving so quickly and developing climate models to prepare us for the future require considerable research efforts, so that we’re not taken unawares,” he says. ●



The underwater robot North Rov is one of Claus Melvad’s inventions. It can completely 3D scan an iceberg below the ocean surface. In another project his students have developed a device that makes it possible to collect water samples from the Arctic Ocean at depths of 300 metres

Read about the project via the link below.

Go online





Assistant Professor Shweta Agarwala is combating e-waste with new, completely biodegradable electronics.

Completely biologically degradable electronics?

That's the aim for Assistant Professor Shweta Agarwala, who's received a Vilum Foundation grant for her new research project, that promises to reduce the ever-growing e-waste problem:

"I think it's high time we start making solutions for replacing the classic materials such as silicon and germanium in electrical components with new biodegradable materials," she says.

Electronic waste, e-waste, is considered the fastest-growing waste stream in the world. In 2019, a record 53.6 million tonnes of e-waste was generated worldwide, up 9.2 Mt in five years. Just 17.4 pct. of this was officially documented as formally collected and recycled. ●

Read online





MULTI-MILLION INVESTMENT IN NEXT-GEN EVBS

Aarhus University is spearheading the development of next-gen electric vehicle batteries (EVBs) that are cheaper, lighter, modular and scalable, more sustainable, and can be recharged in just six minutes.





Photo: Lars Kruse, AU Photo

Today, less than one per cent of the cars on European roads are electric. This is mainly because of the recharging times for batteries, and their short range. Recharging at even the fastest charging stations takes an age, while refueling with fossil fuels takes only a moment.

This difference could soon be history.

In the years to come, researchers from Aarhus University will develop a completely new type of battery for electric vehicles that can be recharged in six minutes and has a range of 350 kilometres. The goal is for the battery to have a lifespan of at least 20 years and be virtually maintenance-free.

“Using an innovative system design and new chemical processes, we want to make an ultra-efficient battery that takes up less space and weighs less. Our idea is to make the battery modular and scalable so that it can be used in trucks and buses as well. This will also make it easy to repair, because you only have to replace the defective part and not the entire battery,” says Assistant Professor Corneliu Barbu from the Department of Electrical and Computer Engineering at Aarhus University.

He’s heading a new project, which may have a major impact on a full European transition to electrified transport.

The idea is to design the battery as a carpet of modular blocks installed under the seats in the car. This will make it possible to maintain a low weight, while at the same time providing greater safety, lower production costs, and significantly more efficient heat management.

“We want to digitalise heat control, and make it intelligent. It is a key element. It takes huge energy transfer to recharge so quickly, and therefore a crucial engineering challenge in our research is to secure a sufficiently high level of safety,” he adds.

Part of the project is for the researchers to develop the charging stations for the new battery. They expect to be able to take their first outing with a prototype of the new battery in just four years, and that it will be ready for commercial production in seven years.

Denmark part of the automobile industry of the future

This will mean that the project could have an impact on a full transition to a green transport sector in Europe, and Denmark could play an important role in the electric car industry together with the other European partners, says Corneliu Barbu:

“The transition will definitely take place over the 2020s. There’s fierce competition to take the lead in battery technology in the motor industry, but it’s not something you can do alone. We believe we’ve got a lot to offer by pooling our knowledge across disciplines and European universities. The design proposal we’re working on is extremely innovative in both materi-

als and electronics, and we’ll be sending all the data from the batteries up into the cloud and using artificial intelligence to create optimum performance and control.”

The researchers will use advanced digital twin technology to develop the battery. This will enable them to avoid errors, make better electronic and computer-technology design decisions, and identify the best choice of material.

“We have great expertise in digital twins, power electronics and battery management systems at Aarhus University. This gives us a significant competitive advantage in the development race,” says Corneliu Barbu.

Sustainability throughout the value chain

Sustainability is an essential part of the researchers’ work on the next generation of batteries. The goal is to make a much smaller carbon footprint than is possible with the batteries in today’s electric cars.

“We’re looking at the entire battery lifecycle, from raw materials to industrial production, distribution, long operational lifetime and then recycling. A circular-economy design perspective is absolutely essential to the project. It’s about creating a cycle of resources where we can reuse raw materials or the entire battery in new applications. This is good for both the environment and the end user’s finances, because the battery is both greener and cheaper to produce,” says Corneliu Barbu.

The project has a total of 18 partners from eight countries and it will run over the next four years. ●

MORE INFORMATION

The EU Horizon 2020 programme has granted a total of DKK 85.5 million (EUR 11.5 million) for the Helios project.

Electric car batteries typically have a capacity of 30 to 60 kWh and usually weigh between 300 and 600 kg.

The researchers aim to develop a prototype for the next generation of electric car batteries with less weight (-30%) and volume (-20%), with a capacity of 350 kWh, and with a full recharging time of just a few minutes.

They are aiming to develop a sustainable system design for the battery, which, among other things, will reduce the need for lithium and significantly improve energy density.

Today, lithium-ion technology is dominant in batteries for electric cars, but it is doubtful whether global lithium deposits will be able to meet demand in a fully electric transport sector.



Contact:

Corneliu Barbu
Assistant Professor
Department of Electrical and
Computer Engineering

coba@ece.au.dk



Photo: iStock

Chemical plant for Haber-Bosch production of ammonia and nitrogen fertilization.

LET'S TALK ABOUT AMMONIA PRODUCTION

Ammonia is one of the most important chemicals manufactured globally today and has lately been envisaged as an opportunity to reduce carbon footprint for a range of industries. Its production however, is currently far from sustainable and carbon-free. A new innovative research project, bridging knowledge from all over the world, aims to change that by finding new ways of producing green ammonia. The project is being headed by engineering researchers from Aarhus University.

A grant of approx. DKK 21 million (EUR 2.8 million) from the EU framework programme for research and innovation, Horizon 2020 will help a research team from the Department of Biological and Chemical Engineering at Aarhus University to lead a global collaboration aiming to develop new technologies to produce green ammonia.

In terms of volume, ammonia is today one of the ten most important chemicals manufactured globally. The substance is primarily used in the production of fertilisers for modern agriculture, but has lately been envisaged as an opportunity to reduce carbon footprint for other industries, for instance the marine sector.

However, ammonia production is currently far from sustainable and carbon-free. The primary method of producing the annual approx. 235 million tonnes of ammonia used the world over is the Haber-Bosch process, which was invented more than 100 years ago.

Green ammonia production

Production costs 1.4 per cent of the world's entire energy consumption and it emits approx. 450 million tonnes of carbon dioxide a year – about 1 per cent of all anthropogenic carbon emissions and more than any other industrial chemical production.

“We want to do something about this, and the project will therefore be looking at the advantages of manufacturing climate-neutral, green ammonia from nitrogen and water in scalable reaction technologies for decentralised, local production. We're taking our outset for the project in three different new technologies, and one of them is an upgrade of the existing Haber-Bosch reactor,” says an expert in ammonia technologies, Assistant Professor Emil Drazevic, who is heading the project called ORACLE.

The three technologies for green ammonia production, that Emil Drazevic and his team of researchers are going to analyse and develop in the project are (A) a Haber-Bosch reactor based on heat from electro-magnetic induction instead of the current heat from incineration (B) a plasma-assisted electro-catalytic concept, and (C) an electro-catalytic concept that uses a special catalyst to catalyse ammonia from nitrogen and water at room temperatures.

“The latter functions as a kind of as a kind of electrolyser, where water and nitrogen are thrown in at one end and oxygen and ammonia come out of the other. The electrolyser only requires energy in the form of renewable electricity. Prior to this project, we completed a very comprehensive survey of suitable catalysts for the task, and it ended up being a very big eye opener. Our Japanese partners in the ORACLE project bring in expertise in water-oxidation catalysts, and we are now extremely excited to have the right team on board and funds to develop ammonia producing electrolysers. I think the final outcome could be a neat and safe technology for producing ammonia at local scale,” says Emil Drazevic.

Aarhus University heads new project

The ORACLE project (Novel Routes and Catalysts for Synthesis of Ammonia as Alternative Renewable Fuel) officially starts on 1 May 2021, and it has a total of eight partners, consisting of two Japanese and three European organisations and their industrial partners.

The project partners are: Aarhus University (coordinator), the Dutch Institute for Fundamental Energy Research in the Netherlands, the Jožef Stefan Institute in Slovenia, the Flemish Institute for Technological Research in Belgium, Osaka Research Institute of Industrial Science and Technology and the National Institute of Advanced Industrial Science and Technology in Japan, as well as the companies C2Cat (Netherlands) and Casale (Switzerland).

The project will run for three years. ●



Contact:

Emil Drazevic
Assistant Professor
Department of Biological and
Chemical Engineering

edrazevic@bce.au.dk



WEB EXCLUSIVE

Mixing carbon-nanofibres with steel fibre-reinforced high-strength concrete: Two engineering students are testing a special kind of concrete for terrorism protection.

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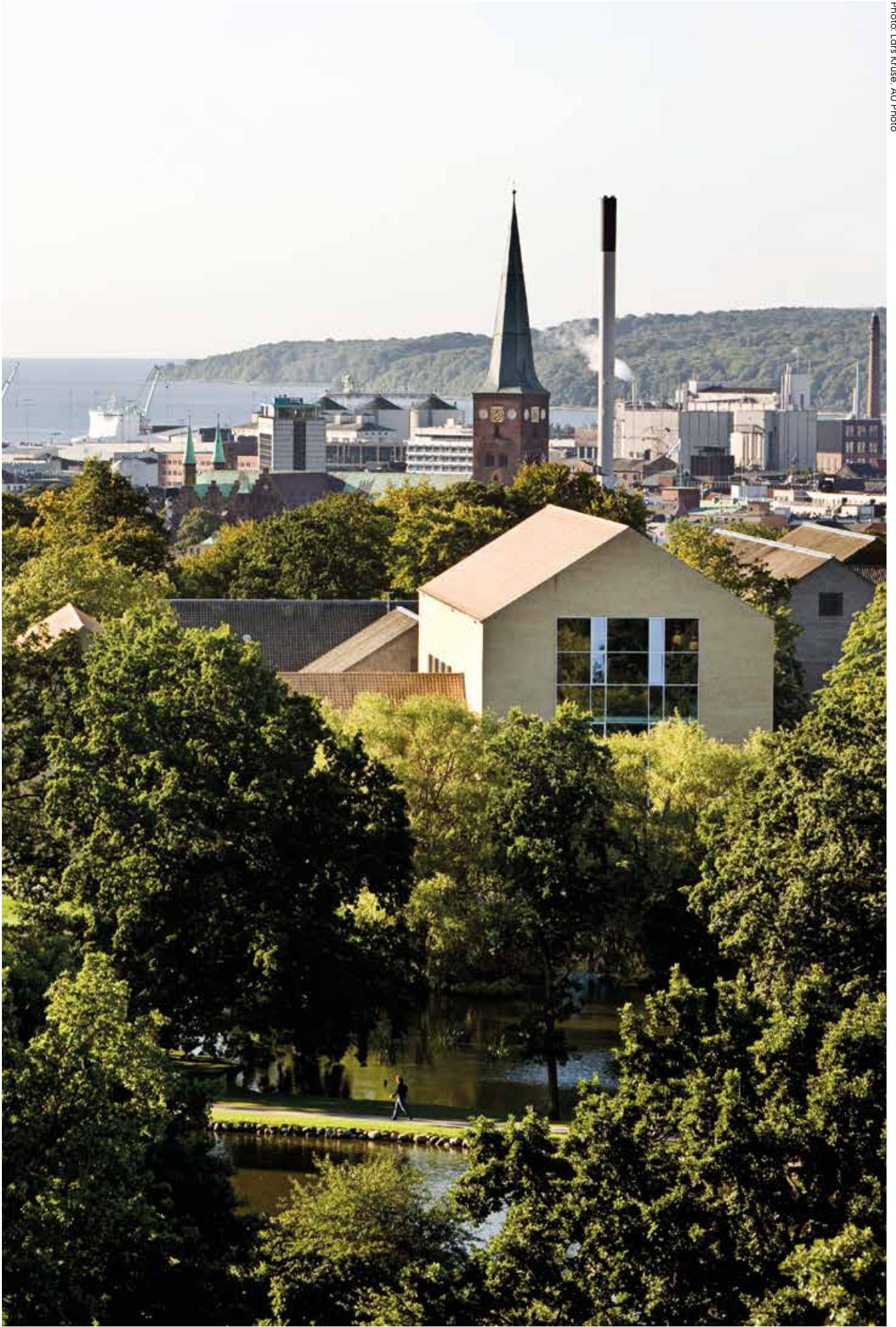


Photo: Lars Kruse, AU Photo

WORK WITH US

The engineering departments at Aarhus University cooperate with a wide range of organisations and companies on research and development projects. As the numerous examples in this magazine illustrate, we help large and small businesses to join the Industry 4.0 wave, we establish innovative partnerships for exploring technological challenges and we cooperate internationally to create insight into international trends. We work with the latest technologies to help companies build or develop new products or components and to process-optimize production chains.

Are you interested in working with the region's leading knowledge institution? We offer various cooperation models.

Collaborative R&D projects and programmes

Our researchers are involved in a large number of national and international research, development and innovation projects in collaboration with companies and universities throughout the world. This extensive knowledge base offers our collaboration partners enormous potential for new knowledge, growth and market opportunities. Working with us, your company can tap into the latest technological knowledge within the engineering sciences to gain valuable insight into technologies that are most relevant for you and your industry. If your company has an idea or a need you want help with, you can collaborate with our researchers on developing your company's technology.

Scientific and innovation networks and clusters

Aarhus University is active in almost every innovation cluster in Denmark, and in many other scientific, technical and busi-

ness-related networks. It may be advantageous for your company to learn more about these networks and what they can offer. You can solve your business problems in collaboration with others, and this is an excellent way to profile your company. You can also develop long-term strategic collaborations with other companies or knowledge institutions.

Innovation collaborations

The engineering departments at Aarhus University have launched a number of initiatives to help companies, especially SMEs in Denmark. For example, our "Smart Industry" programme targeting SMEs with the potential to develop new smart products, services or processes. This is a specific initiative to strengthen growth and innovation for SMEs through more teamwork between companies and knowledge institutions. We also offer cross-disciplinary cooperation combining engineering expertise with researchers from other departments in Aarhus University's strategic research centres.

Combined with a strong and proven approach in applied innovation, we lead and facilitate processes to create new possibilities and solve new challenges. We transform the latest research findings into useful knowledge, products, services and methods for a huge variety of different companies in different branches and of different sizes, ranging from entrepreneurs to SMEs, and from medium sized companies to large organisations.

Get involved

If you would like to explore the opportunities of working with us, contact Business Relations and Partnerships for further information about how we can connect relevant researchers and your interests. ●

Contact

Andy Drysdale
Team Leader
Business Relations and Partnerships

adr@au.dk



He has helped more than anyone else to adorn the flat, Danish landscape with monumental buildings. Now, the award-winning bridge building pioneer Klaus H. Ostfeld has been made an honorary professor at Aarhus University, where he shares his 55 years of experience from Denmark and abroad.

“If only young people today knew what sort of world opens up when you’re a qualified engineer, they’d never be in any doubt about their choice of study”

Klaus Ostenfeld was born and grew up in an era of great vision. During and after the Second World War, engineers were the creators of the world, and technology developed at a fantastic pace.

From when he was very young, he was inspired by names such as Chuck Yeager and Wernher von Braun, with thoughts of huge motors and rockets and dreams of exploring other planets and outer space. Mechanics and technology were his focal point, and Klaus Ostenfeld spent most of his childhood making model trains and

aeroplanes – anything to do with large machinery.

He remembers an episode early on a summer’s day in 1949. He had got up early – before the rest of the family. It had almost been impossible for him to sleep. On the evening before, his father and his three-year older brother had unsuccessfully tried to build a car in Tekno, a Danish model kit with metal parts, that could also take a small motor to get the car to move around.

The six-year-old Klaus had watched them from a distance. He was too young to join in, they thought. But that morning he slipped into the living room and started putting the car together. And when the rest of the family got up, the car was driving around the floor powered by a Helle-sens 4.5 V battery.



It was the first time he realised that he might have a talent for technology.

Interdisciplinarity is paramount

Now 77 years old, Klaus Ostenfeld is probably best known as “the bridge builder of Denmark”. He was the man behind the COWI-led consultancy team for the Great Belt Bridge, and with more than 40 years at COWI, the last eight years as global CEO for the 5000 people company, as well as seven years in foreign companies, Klaus has left his indelible mark on the Danish bridge landscape.

Now he is an adjunct professor at the Department of Civil and Architectural Engineering at Aarhus University, where he wants to give something back after 55 years of experience with major construction.

“Aarhus University is facing huge development within the engineering area, so I thought that it might be a good time to share all the knowledge that I’m carrying around in my head. I may well be in retirement, but if I can help to forge some engineers out of our universities, then I’d love to do so,” he says.

For him, cross-disciplinary insight is the be-all and end-all for a professional approach to engineering, and a solid anchor that he is keen to pass on to the students:

“One cannot alone accomplish anything truly great. Results are always achieved in collaboration with others, and I’m very much in favour of seeking inspiration from other worlds and industries, so that you don’t sit in your own silo and think you know best. You should never do that, because things are evolving all the time,” he says.

He remembers back to construction of the Little Belt Bridge, where, as a young engineering student, he was invited to a meeting with the partners of his uncle’s company, Chr. Ostenfeld & W. Jønson, Consulting Engineers – the forerunner of COWI. Klaus had a burning interest in aerodynamics and enjoyed soaring gliders himself, but he did not know much about bridge engineering back then. But after input from Klaus Ostenfeld, Denmark’s only aircraft constructor, Helge Petersen, was hired to help make the Little Belt Bridge more aerodynamic.

“That episode resounded in my great interest for other sectors, other expertise

areas, and other industries. It’s extremely important to find inspiration in other subjects than your own, and this is particularly relevant for the young engineers graduating from our universities today,” he says.

A milestone on the journey

Despite his early interest in technology and mechanics, Klaus Ostenfeld was not entirely convinced that engineering was right for him. Medicine attracted him at first, and for much of his youth he wanted to be a surgeon. However, he was deterred by the idea of having to memorise anatomy, and he applied for a civil- and structural engineering programme at the Technical University of Denmark instead.

He graduated as a 22-year-old on 31 January 1966 and has never looked back since. After several years in both US and French firms, he returned to Denmark in 1977 when the plans for a bridge over the Great Belt first began to emerge.

The energy crisis stifled all dreams of large bridges in the late 1970s, but the Great Belt Bridge re-emerged in 1988, and Klaus Ostenfeld, at that time director of the bridge unit at COWI, ended up winning the competition to design it.

“I’ve always been fascinated by bridges. Simply standing and looking at them: observing their majestic presence. They don’t do anything in themselves – they’re just there, towering up in the landscape as huge man-made sculptures and allowing people to get from A to B. But bridges are always a special experience, I think. They are milestones on a journey – something you’re waiting for, whether you’re travelling in a train or by car. Connecting people. I’ve always thought so, and that’s probably what made me become an engineer. That and the opportunities the training offers to make a visible difference, also internationally. If only young people today knew what sort of world opens up when you’re a qualified engineer, they’d never be in any doubt about their choice of study.”

Klaus Ostenfeld is 77 years old and lives in Birkerød. In addition to his professorship, he is also an active consultant and sits on a variety of boards. Besides his interests in music and hiking and skiing in the mountains, he is still an active pilot. ●

BIO

Name: Klaus Henrik Ostenfeld

Title: Honorary Professor

Expertise: Bridge Engineering and aerodynamics, tunnel engineering, strategic development and leadership

Age: 77

Residence: Birkerød

Contact

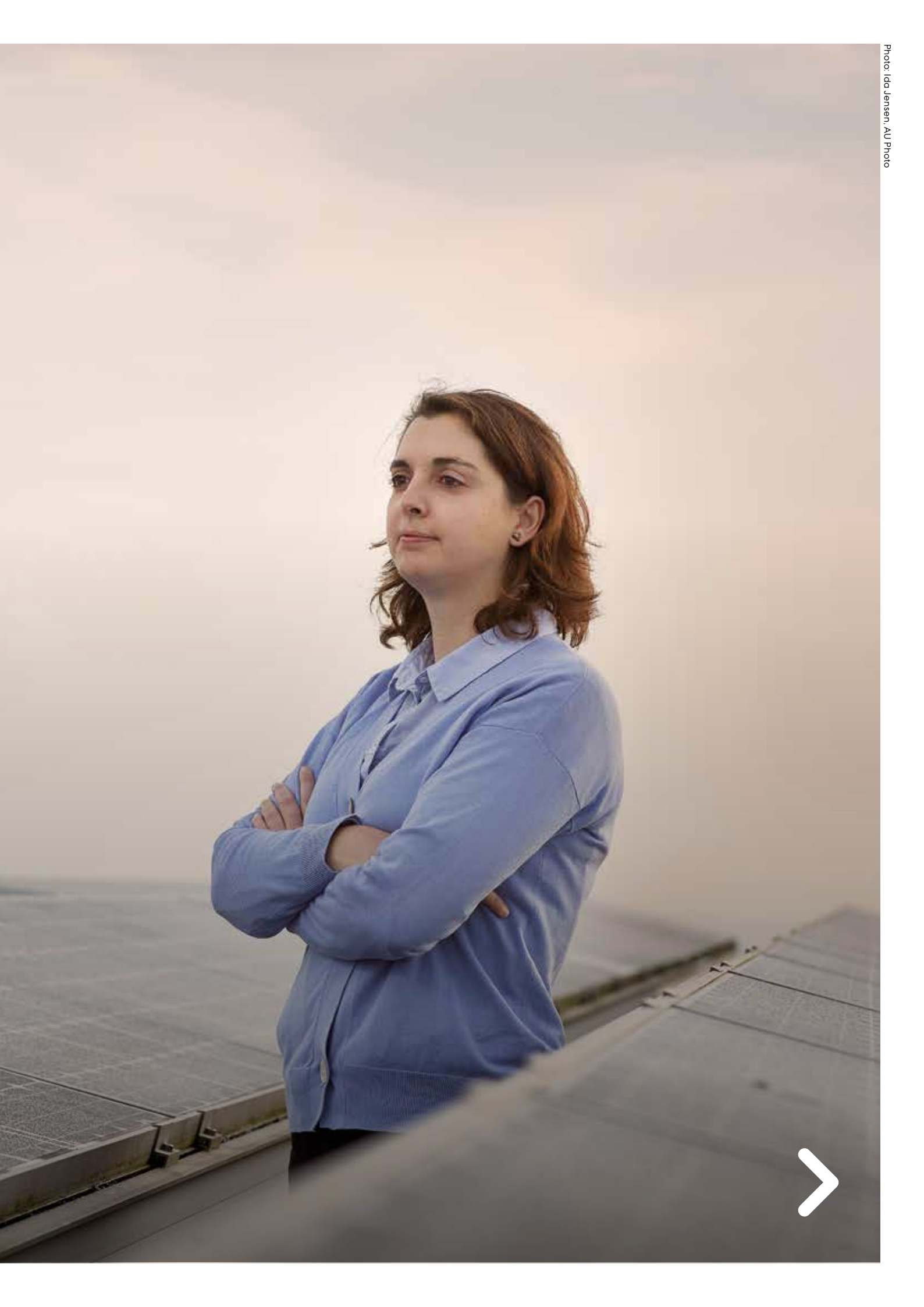
Klaus H. Ostenfeld
Honorary Professor
Department of Civil and Architectural Engineering

kho@cae.au.dk



What's the
cheapest, easiest
way to honour the
Paris Agreement of
limiting the global
warming to 1.5
degrees Celsius?

**Solar energy.
Lots of it.**



Green energy transition: Early and steady wins the race

Researchers from Aarhus University have modelled the decarbonisation of the sector-coupled European energy system using very high-resolution data. The results are clear: To reach climate-neutrality by 2050 we need solar energy.

What's the cheapest, easiest way to honour the Paris Agreement of limiting the global warming to 1.5 degrees Celsius? A clear and strong investment in wind and solar power. Starting now.

That's the message in a new scientific paper published in Nature Communications, where Aarhus University researchers have modelled the decarbonisation of the sector-coupled European energy system using uninterrupted high-res hourly data for every European and Scandinavian country and network interconnectivity.

Using the university's supercomputer, PRIME, the researchers have modelled how to modify the production of electricity, heating and transport sector energy, so to make sure that there's enough of everything for every possible hour, even in the coldest weeks of winter.

"We ask the question of which energy strategy to employ in order to reach the 2050 goal. We have a 'carbon budget' – a maximum amount of CO₂ we can emit – and how do we make sure, that by 2050 we reach climate-neutrality in the cheapest and most feasible way?" asks Assis-

tant Professor Marta Victoria, an expert in photovoltaics (PV) and energy systems at the Department of Mechanical and Production Engineering, Aarhus University.

She continues:

"There are two scenarios: 'Early and steady' or 'late and rapid'. Our model clearly shows that the cost optimized solution is to act now. To be ambitious in the short term. And we find solar energy and onshore and offshore wind to be the cornerstone in a fully decarbonised 2050 energy system."

Marta Victoria highlights, that both paths require a massive deployment of wind and solar PV during the next 30 years.

Not an easy task

The required installation rates are similar to historical maxima making the transition challenging, yet possible.

"It's not an easy task," she emphasizes:

"In some years, we will have to install more than 100 Gigawatts of solar PV and wind power, and to achieve full decarbonisation the CO₂ prices will have to be a lot higher than today."



Contact:

Marta Victoria
Assistant Professor
Department of Mechanical and
Production Engineering

mvp@mpe.au.dk

The paper illustrates a slowly inclining CO₂ price that maximizes around 400 €/ton in the year 2050 – around 20 times higher than today's prices. Needed, in order to favor the renewable transition, Marta states.

The model also includes hydro power and – to account for so-called 'nightmare weeks' – a small amount of gas-based electricity and heating production plus energy storage facilities:

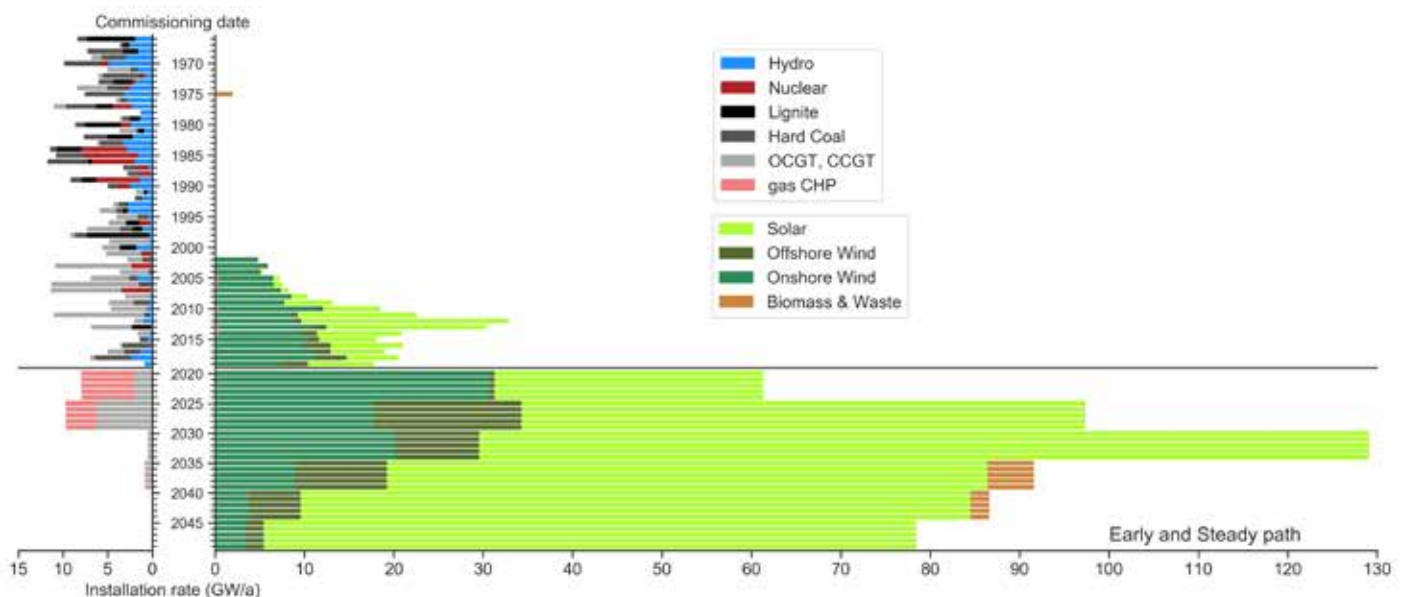
"District heating systems are efficient for very cold and critical periods where electricity demand and heating demand is high, but wind and solar energy production is low, but wind and solar energy production is low. Large hot water tanks discharge during those weeks. This way we make sure, that the future energy systems works for every possible scenario."

The research has included every energy resource including nuclear energy, but optimized for cost and feasibility, the model clearly favors solar, wind and hydro. The research has been conducted in cooperation with researchers from Karlsruhe Institute of Technology and is part of the RE-INVEST project funded by Innovation Fund Denmark. ●

“

In some years, we will have to install more than 100 Gigawatts of solar PV and wind power, and to achieve full decarbonisation the CO₂ prices will have to be a lot higher than today”

Assistant Professor Marta Victoria



A massive expansion of wind and solar is needed during the next 30 years in Europe. The graph shows, on the top, the historical annual installed capacities for different technologies and, on the bottom, the required future annual installations for wind and solar to attain zero emissions in 2050. Figure: Marta Victoria.

Aarhus University



WEB EXCLUSIVE

Today, drones can autonomously carry out various tasks with zero or minimum involvement by human operators. However, they need to fly as slow as possible to sense their environment and plan future actions. But what if drones need to fly fast like in a manual drone race where speed, agility, and performance are paramount? A team of researchers from Aarhus University have taken a step forward.



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Future green construction sites

In 2016, the construction sector discharged approx. 3,500 tonnes of NO_x (nitrogen oxides) and approx. 320 tonnes of PM2.5 (fine particles with a diameter measuring < 2.5 µm), corresponding to 10 per cent and 46 per cent of the total emissions from road traffic, respectively. The industry is responsible for 2.2 per cent of total CO₂ emissions in Denmark.

The Danish Energy Agency estimates that on-site transportation, such as heavy machinery, accounts for one third of Denmark's total consumption of oil.

Less than 5 per cent of energy consumption by the construction sector is from renewable sources.





New partnership to make building sites greener

There hasn't been much focus on the green transition of the construction industry – but there's a lot to be gained. The sector accounts for a large percentage of total emissions and more than 2 per cent of all carbon emissions in Denmark.

Six companies and two research institutions have now joined forces to establish a full-scale demonstration building site as it may look in a green future.

"Recommendations to the Government from the Climate Partnership for the Construction Sector" was published in March 2020, and the report states that the construction industry "must develop its mindset from just financial aspects to an overall economic/climate bottom line".

The reason is simple, but has been overlooked for a long time: In 2016, the sector discharged approx. 3,500 tonnes of NO_x and approx. 320 tonnes of PM2.5 (fine particles with a diameter measuring < 2.5 µm), corresponding to 10 per cent and 46 per cent of the total emissions from road traffic, respectively. The sector was also responsible for 2.2 per cent of total CO₂ emissions in Denmark.

This was also why, back in 2019, governments in Copenhagen and Oslo entered into a partnership on procuring climate-friendly construction plant, and in September 2020, Denmark reached a milestone with the first emissions-free

building site for a daycare institution in Vanløse, located west of Copenhagen, called Mundi.

Now, six companies (Per Aarsleff, Volvo Entreprenørmaskiner, Katzenmark, Purefi, Airlabs and Alumichem) have teamed up with the Danish Technological Institute and Aarhus University in a lighthouse project to take the next step.

The project is called the 'Future Green Construction Sites', and basically it will demonstrate green elements on a construction site through modern technological solutions in interaction with efficient operations and intelligent logistics.

Among other things, the project will develop a digital construction site model; a Digital Building Twin (DBT), which visualizes and optimises workflows via real-time sensor data.

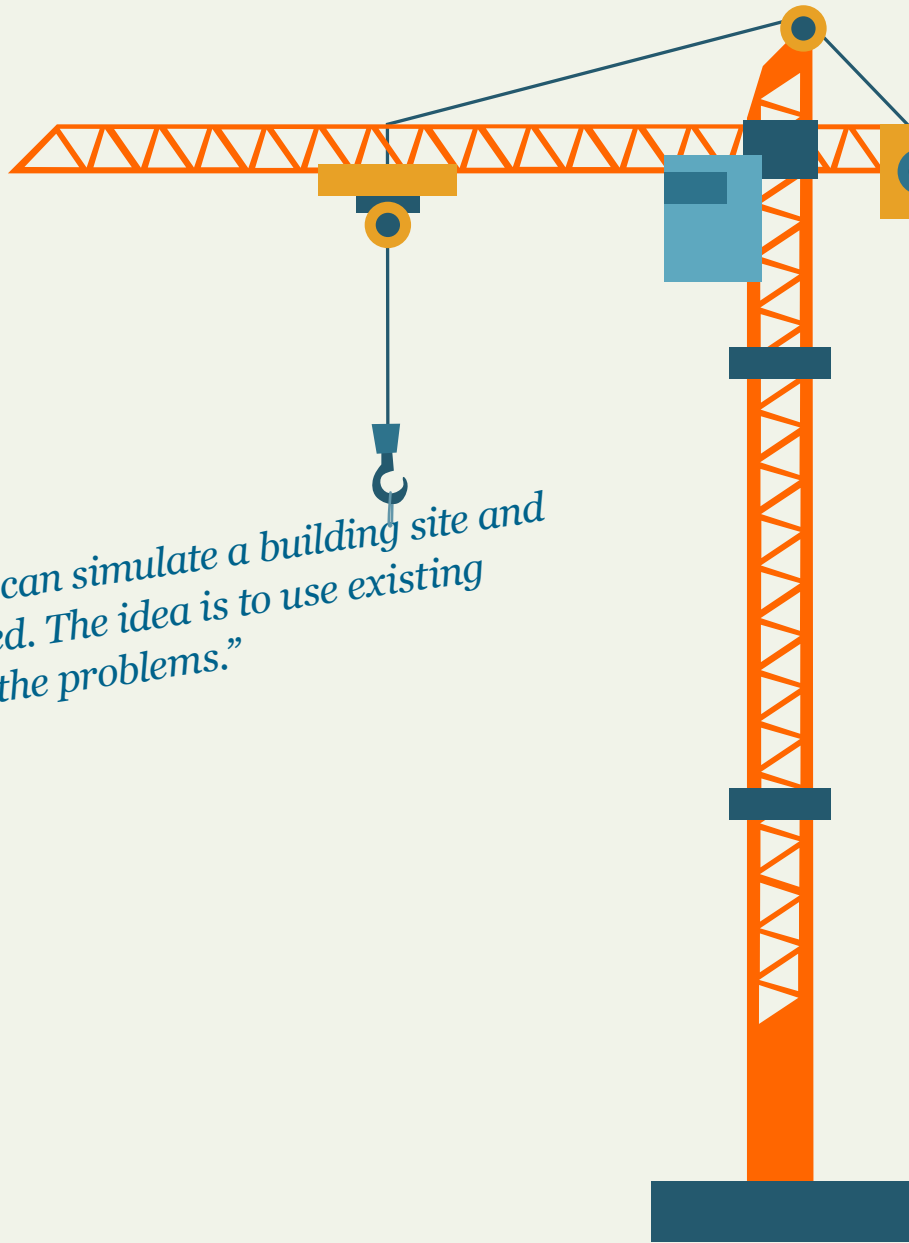
"Our goal in the project is to track resources



Contact:

Søren Wandahl
Professor (Docent)
Department of Civil and
Architectural Engineering

swa@cae.au.dk



“

Using the digital twin, we can simulate a building site and see how it can be optimised. The idea is to use existing technologies to deal with the problems.”

Professor Søren Wandahl



Contact:

Jochen Teizer
Associate Professor
Department of Civil and
Architectural Engineering

teizer@cae.au.dk

on construction sites and see whether we can find potential for improvement. We then want to find out whether it's possible to reduce energy consumption and emissions. Using a DBT, we can monitor the construction operations in real time and optimise the processes over time,” says Associate Professor Jochen Teizer from the Department of Civil and Architectural Engineering at Aarhus University, who is responsible for developing the digital twin via Building Information Modelling (BIM).

Actual measurements of energy consumption and emissions have not received much focus in the construction sector in the past. Today, however, there is already a wealth of technologies being used in other sectors that can be adapted in construction.

The Future Green Construction Sites project will be based on these existing technologies, explains Professor Søren Wandahl from Aarhus University.

“Using the digital twin, we can simulate a building site and see how it can be optimised. The idea is to use existing technologies to deal with the problems. Initially, it's a question of looking at where the biggest emissions are, and whether there's anything we can do to reduce them,” he says.

The project started on 1 January 2021 and will run until the end of 2023. The total budget for the Future Green Construction Sites project is DKK 27 million (EUR 3.6 million). ●



Robotic colleague takes over the production line at Aarhus factory.

“Many Danish SMEs are increasingly concerned about losing their competitiveness abroad, and I really understand that. But many of them have yet to see the potentials in Industry 4.0. That’s a shame, because opening up for these opportunities, including robots, is just fantastic, and there’s actually a lot on offer for companies like us to help us start using them.”

Director and co-owner at Jydsk Emblem Fabrik A/S Hanne Hørup in January, when an intelligent, mobile robotic manipulator system was demonstrated at her factory.

The demo day was part of a collaborative project instigated by Aarhus University’s Industry 4.0 development programme, Smart Industry. ●

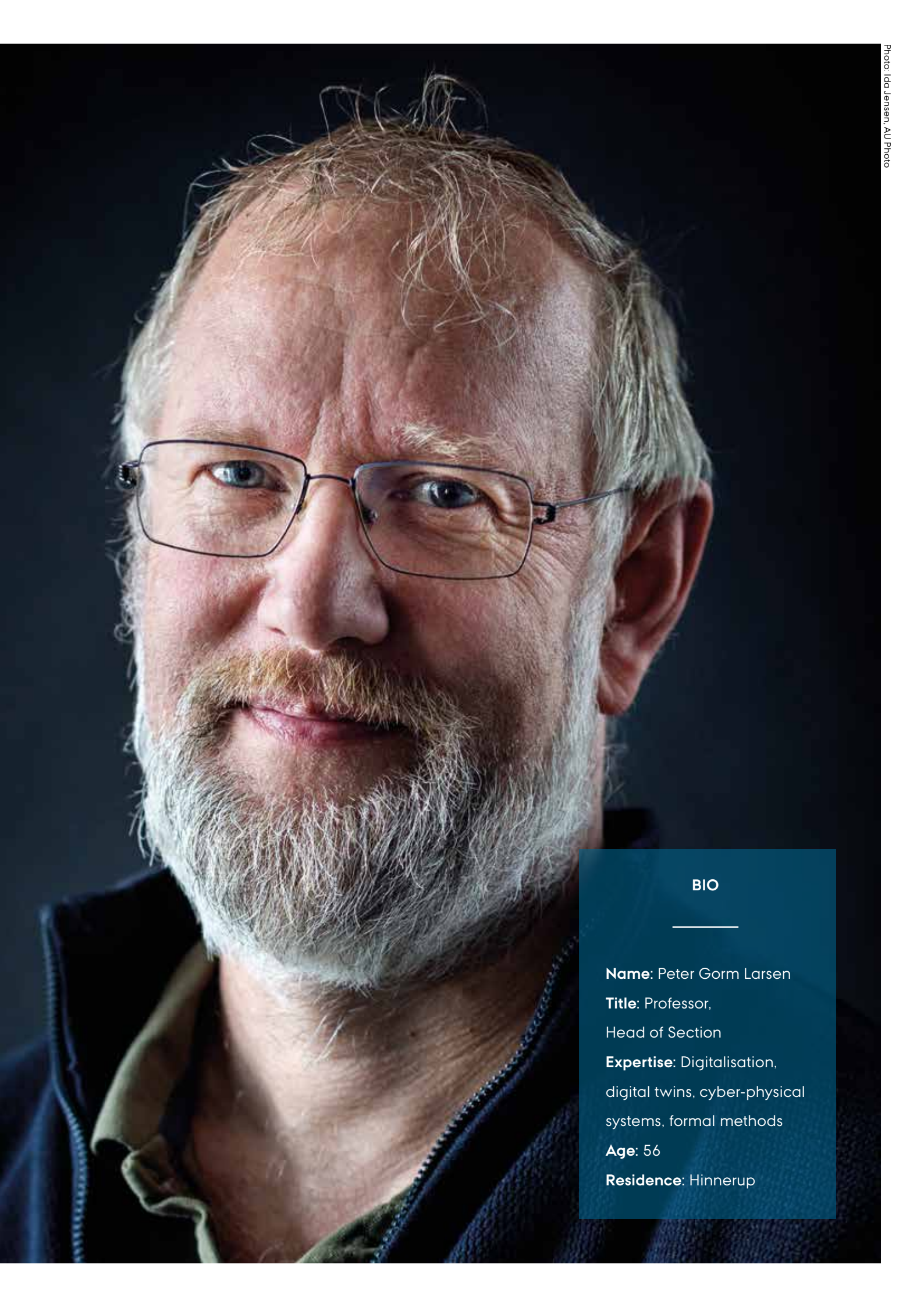
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DIGITAL TWINS: DISRUPTING THE NORM

Professor Peter Gorm Larsen, head of the AU Centre for Digitalisation, Big Data and Data Analytics (DIGIT) and figurehead of the university's investment into the hyped technology of digital twins.





BIO

Name: Peter Gorm Larsen

Title: Professor,
Head of Section

Expertise: Digitalisation,
digital twins, cyber-physical
systems, formal methods

Age: 56

Residence: Hinnerup

Digital twins are without doubt the future for the manufacturing industry. The technology could completely disrupt the normal way of developing products.

At Aarhus University, Professor Peter Gorm Larsen has spearheaded the development and planning of a multitude of industry-related projects within digital twins. Everything is consolidated at the university's Centre for Digital Twins, and with a total budget of more than DKK 750 million secured within the first two years, the professor sees developments moving only one way: forwards.

For Peter Gorm Larsen, it all started back in 2018, when the Poul Due Jensen Foundation tapped him on the shoulder to offer support for his future research.

More than 100 companies, over 50 knowledge institutions, a bulging project bank anchored in different pan-European networks, and more than DKK 750 million in research project funding from different organisations (DKK 75 million of that alone reside at AU). Within just two years, Aarhus University has become a magnet for research, innovation and business collaboration in the field of digital twins, and behind it all is one professor: Peter Gorm Larsen.

The university officially opened its Centre for Digital Twins in May 2019, and since then Peter Gorm has been busy exploring the many new opportunities in this promising technology.

"There's a huge need in industry to clarify whether this technology can add value. And if we are to succeed in the fierce international competition, companies, authorities and universities have to work together on the digital front. I hope that we can help many Danish organisations to overcome their initial challenges and embark on their digitalisation journey," he says.

This idea also lies behind the collaboration on the Digital Transformation Lab in Ringkøbing-Skjern Municipality (see page 10-11), which also centres on the professor. The plan is for more projects and new

collaborations, across sectors and with partners from across national borders.

For Peter Gorm himself, his digital twins journey started many years ago.

The whole concept of digital twins was originally born during the Apollo 13 mission in April 1970. Back then, Peter Gorm Larsen was six years old and not very interested in his school lessons. Sport was his major enthusiasm, and it remained so throughout his schooling, so that his long-term plan was to work in a sports shop, while most of his school friends went on to become fishermen.

Peter was bored when he left school, and he had no plans to go on to upper secondary education. He had an apprenticeship in a sports shop, and he never thought about further education until the owner happened to say to Peter that if he wanted to take over the shop one day, he would be well advised to consider taking a business qualification.

In August 1979, Ringkøbing County was forward-looking and opened the new Ringkøbing Gymnasium upper secondary school for students. In the following year, a young Peter Gorm jumped on the band-wagon. He didn't send his application until a month after the deadline, but fortunately he got in. Upper secondary



Contact:

Peter Gorm Larsen
Professor, Head of Section
Department of Electrical and
Computer Engineering

pgl@ece.au.dk

“

I'm glad that the municipality where I grew up is leading the way, because I want to give something back to my old county, who back then decided to build an upper secondary school in Ringkøbing. If they hadn't, I'd never have continued education after lower secondary school,”

Professor Peter Gorm Larsen

ABOUT DIGITAL TWINS

A digital twin is a complete digital model that approximates to a physical system (a cyber-physical system). For example, a process or a unit. A digital twin is so accurate that it acts, reacts, ages and fails in the virtual world in exactly the same way as the physical twin in the physical world.

A digital twin can give manufacturing companies a completely new layer of technical insight that can prove invaluable in developing or improving products or in generating ideas for the next generation of the product.

Digital twins emerged as a concept in connection with the Apollo 13 mission. For the first time, engineers at NASA attempted to simulate the importance of changes in the space capsule from their base on Earth before the changes were implemented by the stranded astronauts in space.

The technology was picked up on by the manufacturing industry for the first time in 2002.

school opened Peter's eyes to subjects he actually found exciting. Mathematics, physics and technology at a general level.

This led to him applying for an engineering degree programme at the Technical University of Denmark (DTU) in 1983.

After obtaining his MSc in Engineering, Peter worked in the private sector for 17 years, including at a non-profit organisation called the Institute of Applied Data Technology (IFAD) and later Systematic, before he was appointed associate professor at Aarhus School of Engineering in 2005. Underway, he took an industrial PhD, and when Aarhus University and Aarhus School of Engineering merged in 2012, he moved to the new Department of Engineering as a professor.

Peter Gorm Larsen is currently one of the pioneers of research into digitalisation, cyber-physical systems and digital twins. The latter took off in earnest in 2018, and Peter Gorm gives the honour for this to the Poul Due Jensen Foundation.

“They came and tapped me on the shoulder in 2018, saying, ‘we'd like to support you in your future research, if we can find a good research area’. This was a strange experience for me, because I was used to going out and applying for funding from others, rather than having them come to

me with project funding,” says the professor.

Therefore, he sat down and wrote a document about all the research he had done, and what he saw as the important direction for research into digitalisation for the future. There were three vision areas on his list, one of which was digital twins.

The funding resulted in Aarhus University's Centre for Digital Twins, and the journey has only just begun:

“A lot of companies will have to join this digital transformation journey, and Ringkøbing-Skjern Municipality is showing the way as ‘early movers’. This demonstrates a willingness to embrace modern technology that is so vital for our manufacturing industry. I'm glad that the municipality where I grew up is leading the way, because I want to give something back to my old county, who back then decided to build an upper secondary school in Ringkøbing. If they hadn't, I'd never have continued education after lower secondary school,” says Peter Gorm Larsen.

Professor Peter Gorm Larsen is currently the head of section for Software Engineering and Computing Systems at the Department of Electrical and Computer Engineering at Aarhus University. ●



Researchers from Aarhus University, Danish Technological Institute and the John Hopkins University have joined forces to enable the use of high-fidelity data-driven wake models for wind farms making them more energy efficient.

"Present engineering practice relies on low-order so-called 'engineering wake models'. These models are mainly deterministic and based on several simplistic physical assumptions under idealized conditions. Because of that, such models fall short in the prediction of wind flow and power production in real environments. This can cause errors and uncertainties in the optimization algorithms and control strategies in wind-energy projects," says Associate Professor Mahdi Abkar, an expert in fluid dynamics at Aarhus University. ●

Read online





Using an unusual, light-dependent enzyme and a newly discovered enzymatic mechanism, researchers from Aarhus University and Massachusetts Institute of Technology have enabled the biological synthesis of high-yield industry relevant production of climate neutral drop-in fuels from biowaste.



New discovery opens novel pathway for high-titer production of drop-in biofuels



Photo: Jingbo Li, MIT

The lab-setup of the light incubator showing two different experimental blue light setups.

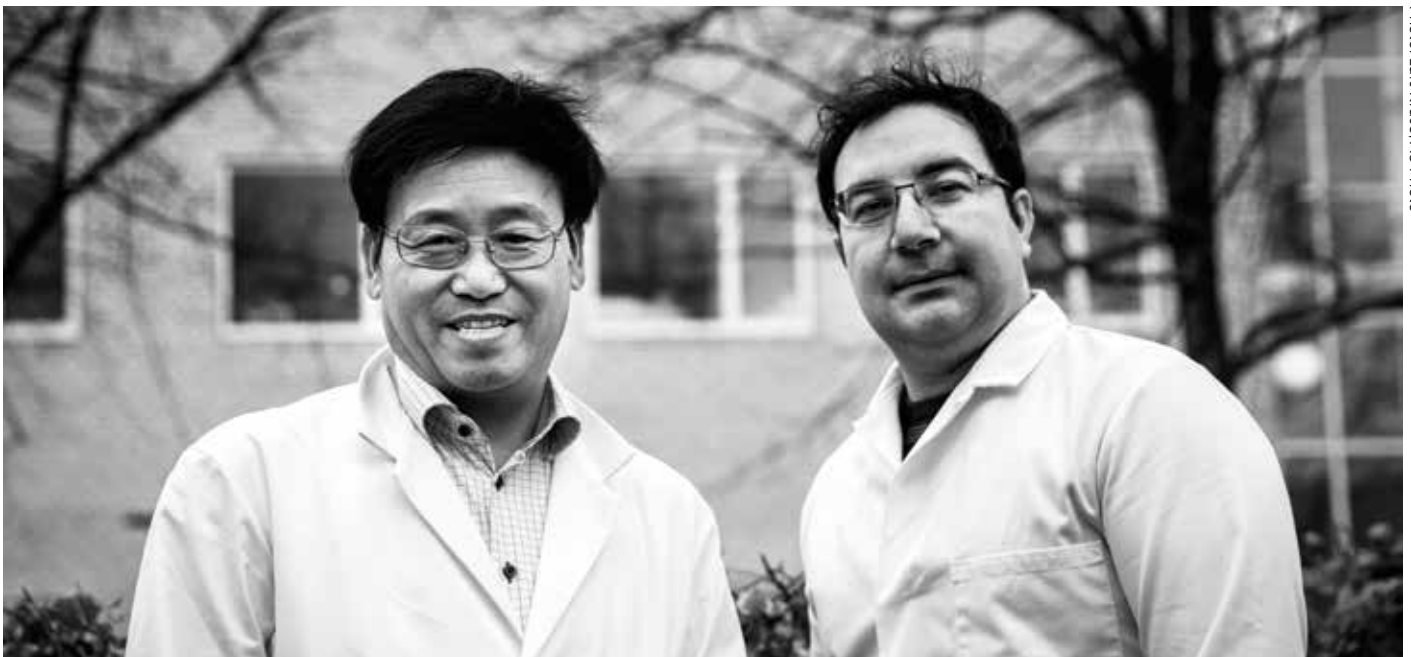


Photo: Lars Kruse, AU Photo

The new discovery is a possible breakthrough in biosynthesis of drop-in fuels, since the researchers – for the first time ever using this process – have utilized the new knowledge to synthesize green fuels at a level that's relevant for future industrial production.

On picture is Associate Professor Zheng Guo (left) and Assistant Professor Bekir Engin Eser (right).

A special light-dependent enzyme, which was first discovered about three years ago, is the focal point in a new scientific discovery, that enables high-yield production of drop-in biofuels from biomass.

In a study published in *Nature Communications*, engineers from Aarhus University and Massachusetts Institute of Technology have proved, that the original assumption of the enzymatic process in this biomass-to-biofuels conversion is actually wrong.

The findings have allowed the researchers to successfully biosynthesize green fuels at close to industrially relevant levels of 1.47 gram per liter from glucose.

Getting the FAP right

The light-dependent enzyme, which originates from microalgae, has the particular characteristic that it can decarboxylate fatty acids into alkanes (thus converting cellulosic biomass into drop-in biofuels) using blue light as the only source of energy.

The researchers artificially insert the enzyme into the cells of the oleaginous yeast *Yarrowia Lipolytica* thereby engineering its metabolism. The yeast synthesizes glucose, originating from biomass, into lipids (specifically the molecules free fatty acids and fatty acyl-CoAs) which is then converted to alkanes by the enzyme in a metabolic reaction called fatty acid photodecarboxylase, in short FAP.

But ever since the discovery of the enzyme, it has been assumed, that free fatty acids are the enzyme's preferred reactant in the FAP process. That an abundance of free fatty acids would result in higher yield biofuel production.

Wrong, however.

"In our study, we have proved that fatty acyl-CoA – and not free fatty acid – is the preferred reactant for the light-dependent enzyme. This finding has been successfully used in our study to metabolize 89 per cent of fatty acyl-CoA into alkanes, reaching titers of 1.47 g/l from glucose," says Bekir Engin Eser, assistant professor at Aarhus University.

Biosynthesis of fuels

The predominant production of oleochemical based drop-in fuels today are

made by converting 'conventional' oleochemicals such as vegetable oils, used cooking oils, tallow, and other lipids to hydrocarbons (mainly alkanes) using energy intense chemical treatment methods.

However, sourcing large quantities of more or less sustainable lipid feedstocks at a low enough cost to result in profitable drop-in biofuel production remains a challenge that severely limits the expansion of this production platform. And furthermore, this production is competing with food supply.

Biosynthesis constitutes a cheap and sustainable solution, where the production is instead based on the conversion of cellulosic biomass – the most abundant renewable natural biological resource available on Earth.

Opens for higher titers in future studies

Biological synthesis of alkanes from fatty acids is not a native, preferable metabolic pathway for the yeast however, since alkanes are toxic to its cells. Therefore, researchers use special ability enzymes for this purpose and encode the corresponding genes into the cells of the yeast.

The new discovery is a possible breakthrough in biosynthesis of drop-in fuels, since the researchers – for the first time ever using this process – have utilized the new knowledge to synthesize green fuels at a level that's relevant for future industrial production:

"Previous metabolic engineering studies would target maximizing the concentration of free fatty acids in the cells that are being engineered. But now, with this discovery, we know that it is fatty acyl-CoA that needs to be maximized. This is important news for synthetic biology applications, and we can now begin to maximize the flux of the fatty acyl-coA into this engineered metabolic pathway to reach even higher titers in the future," says Associate Professor Zheng Guo from Aarhus University. ●

Contact:

Zheng Guo
Associate Professor
Department of Biological and
Chemical Engineering.

guo@bce.au.dk

Bekir Engin Eser
Assistant Professor
Department of Biological and
Chemical Engineering.

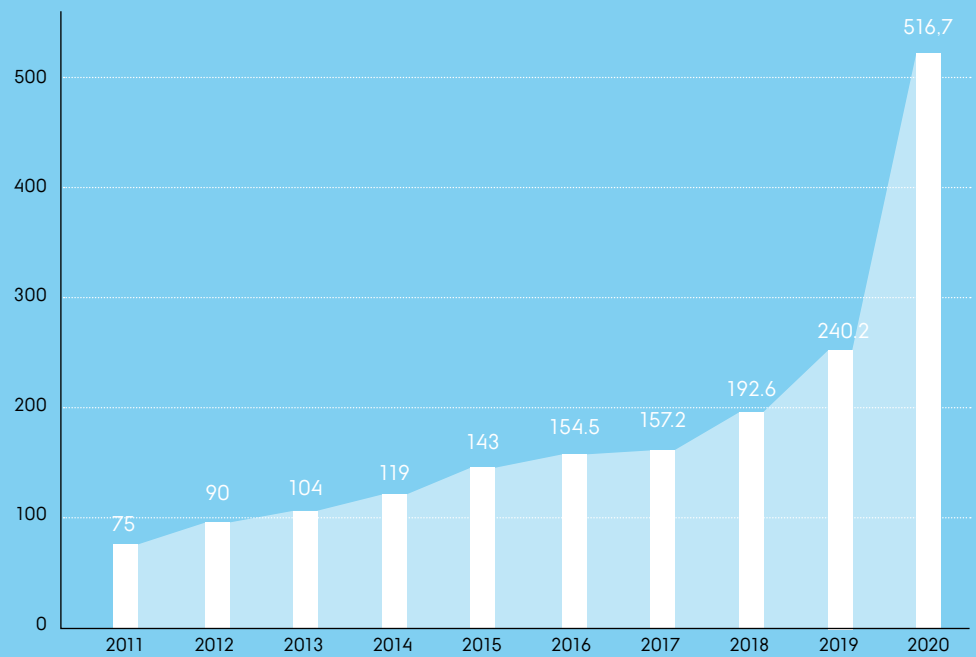
bekireser@bce.au.dk

KEY FIGURES

AU ENGINEERING, AARHUS UNIVERSITY

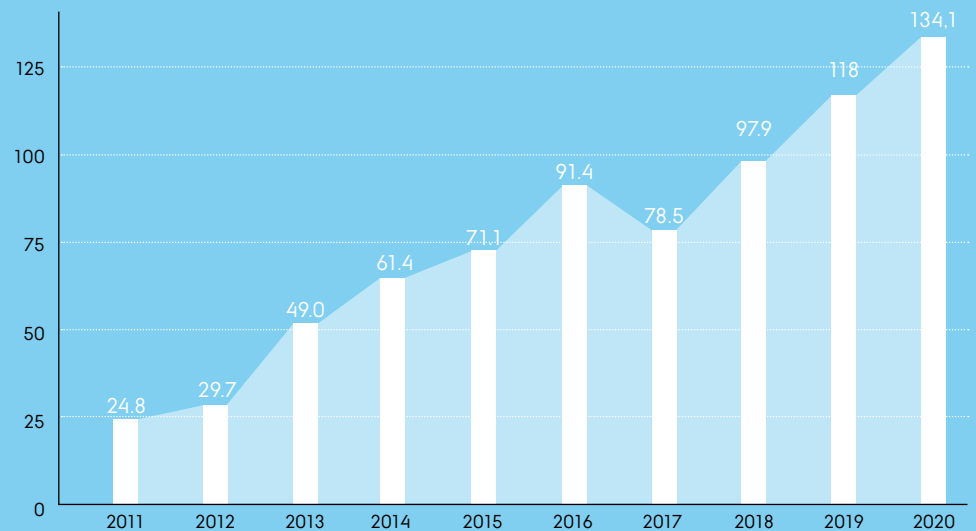
TOTAL ENGINEERING TURNOVER (M DKK)

Based on annual FC3 budget

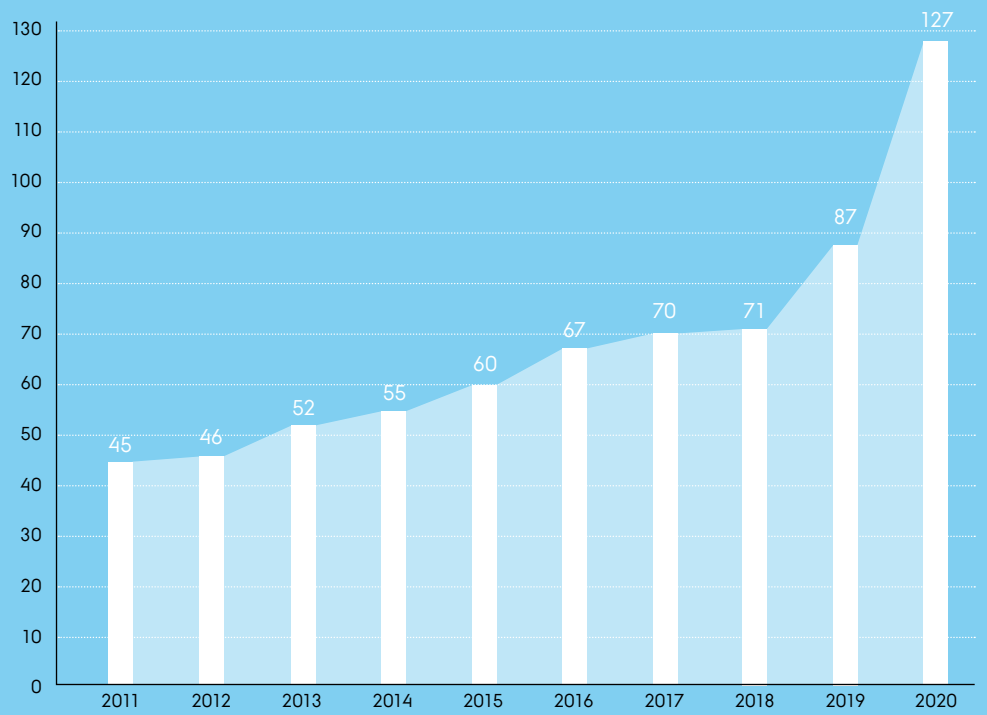


EXTERNAL FUNDING TOTAL (M DKK)

2020 is based on annual forecast budget

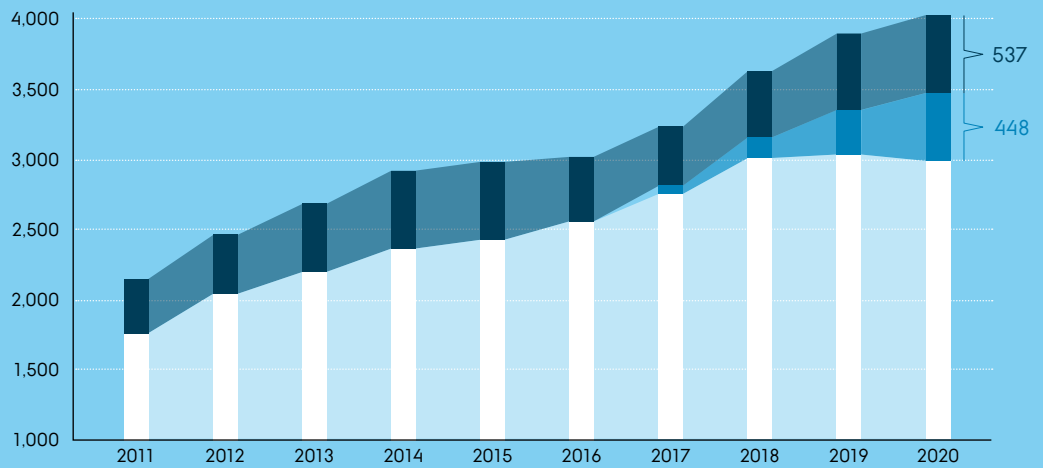


ENGINEERING PHD STUDENTS



ENROLLED ENGINEERING STUDENTS

- MASTER OF SCIENCE IN ENGINEERING
- BACHELOR OF SCIENCE IN ENGINEERING
- BACHELOR OF ENGINEERING



WEB EXCLUSIVE

Associate Professor Qi Zhang is heading an international research project that will make it possible to read data directly from compressed IoT data. The project is carried out in collaboration with the Department of Computer Science at Aarhus University and experts from the Massachusetts Institute of Technology, Boston University, Terma and Energinet.

Go online



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Agriculture is facing a paradigm shift. The majority of the country's cultivated area is used for livestock feed production. But what if we could get a lot more meat out of a much smaller area?

New technology now allows us to clear a completely different path for farming. A path that can initiate a pervasive green transformation of the entire society.

[Read inside, p. 12](#)

CONTACT

AU Engineering
Faculty of Technical Sciences
Aarhus University
Inge Lehmanns Gade 10
DK-8000 Aarhus C
Denmark

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