PROFILE 2022

AU ENGINEERING

RESEARCH
COLLABORATION
EDUCATION

THE ENERGY AND WILD IDEAS

Celine's Bachelor's project was a cornerstone in a new waste-seperation technology developed in an industrial collaboration. **"Remember the engineering students," says company CEO and project partner**

+

SURGEONS AND ENGINEERS

New healthcare-tech is developed in collaboration with industry and the health sector.

+

SMART INDUSTRY

Increasing demand for automation led to partnership with AU on new robot technology.

+

EXPERIMENTAL CONSTRUCTION

Denmark's first 3D-printed house was built in Holstebro. Hasan tells the story.

AARHUS UNIVERSITY
AU ENGINEERING

SOLIDUM PETIT IN PROFUNDIS · UNIVERSITAS ARHUSIENSIS

DAILY MANAGEMENT 2022

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

Contact: contact@auengineering.au.dk

engineering.au.dk/profile

Photo: Jesper Rais

AU research center in Foulum.

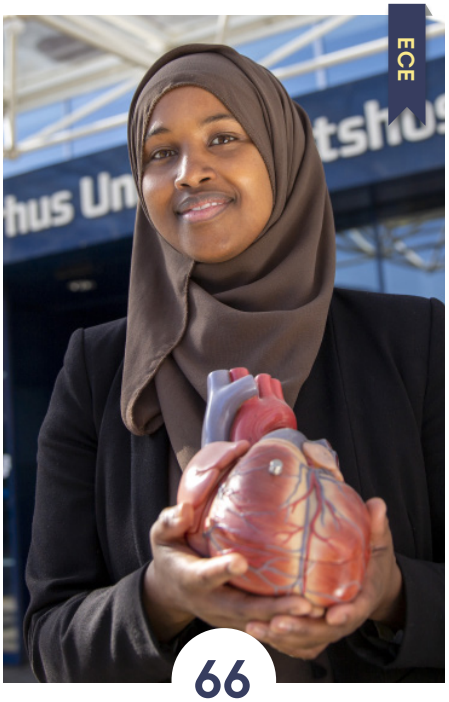
CONTENTS

42

Testing ideas close to risk-free
Engineering interns: A mutually beneficial opportunity.

The future of healthcare tech
Clinicians and engineers team up to develop next-gen technologies.

55



66

Keeping Denmark at the front
Collaboration is a must, if we are to maintain momentum for Danish competitiveness.

Photo: Lars Kruse, AU Photo

Associate Professor Morten Knudsen lecturing civil engineering students.

The changing face of university-business collaboration

Changes in the broad economic, political, societal, environmental and technological development are creating a greater sense of urgency around our research and educational activities at AU Engineering.

Our ambition is to be a collaborative and solution driven engineering faculty and to build ever closer relationships to the business community around us focusing our skills and knowledge on the green and digital transition.

This may sound obvious. What else would a dean say in an editorial to a university profile magazine about technology and engineering sciences?

The case is that our ambition is very close to my own heart. I consider this as the most important leadership challenge in my career, and it is far from trivial.

A revised agenda for future research
In 2022 we are not only focusing on technology transfer mechanisms that lead to commercialization of research insights, new technologies and intellectual property, higher productivity or economic growth in the business community. We are widening our university-business collaboration practices with an increasing joint focus on producing impact that contributes to a better world.

This is also a revised agenda for the direction of our future research and education. We are facing societal changes of unprecedented scale and scope and if we want to transform industrial practices, digital processes, energy production, and distribution systems we must focus on new and multidisciplinary transition pathways, and engage in closer collaborations even with companies we did not share interests with only a few years ago.

A warning of what might lie ahead
The current supply and energy crises are a warning of what may lie ahead, even after a green energy transition. Consumption behavior, disruptive production innovation, new ways of transportation, and cultural and political differences must be taken into account in future technological research and development.

The focal point for our engineering departments is the green and digital transition of society's current linear fossil economy to a circular bioeconomy: a society where nothing goes to waste, where no fossil resources are dug out of the ground, and we have acceptable alternatives for everything we dig up today.

This requires university-business collaboration on a new level. Together, we can generate knowledge and technological progress to help solve major local and global societal challenges. We want to fully integrate the technological challenges facing industry into our educational and research activities. We want to create much better conditions for demand-driven collaboration with private companies and public-sector institutions alike and a better basis for innovation and growth.

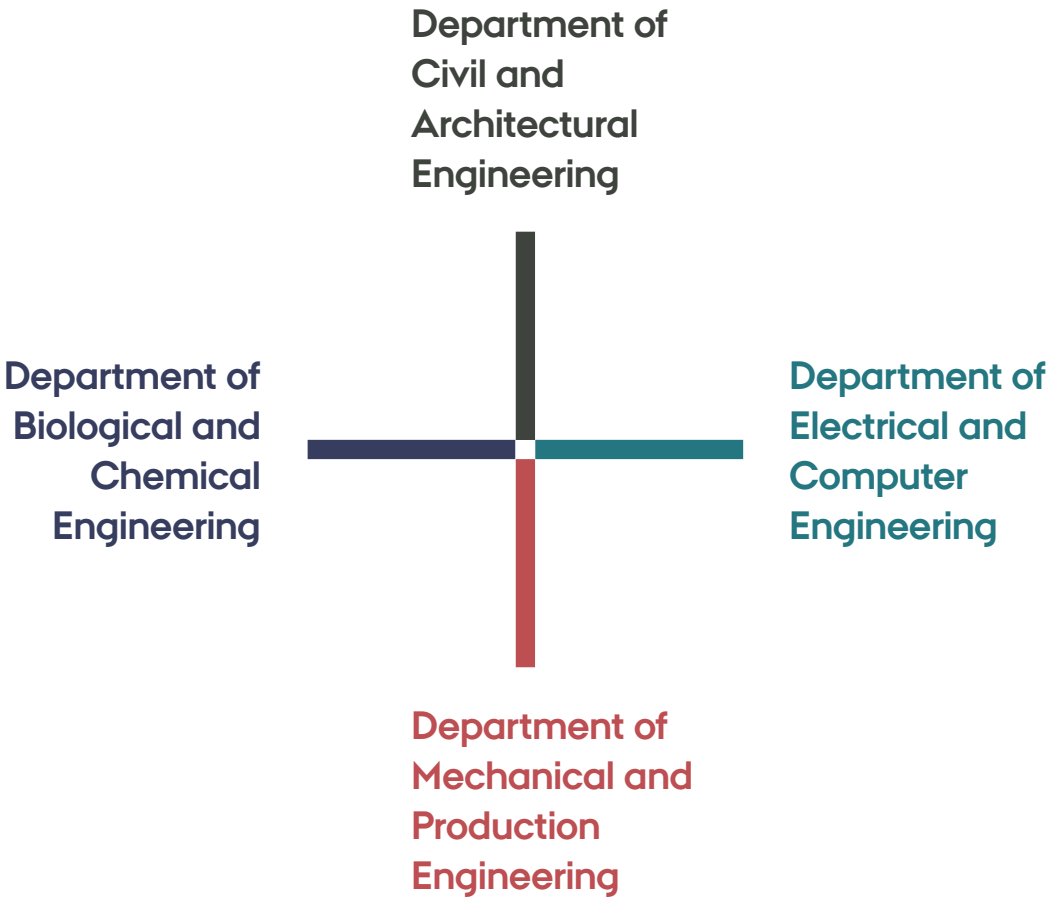
Be inspired in the collaborations and partnerships highlighted in this magazine.

Happy reading!

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

Photo: Lars Kruse, AU Photo

Fall in the Aarhus University park.



Engineering is key in the technological revolution and the digital and green transitions. It is the link between deep theoretical science and its creative application, and for centuries, engineers have changed the world; for better and for worse.

Since 2016, Aarhus University has been deploying a major initiative for the engineering area: AU Engineering. The aim is to forge internationally leading research and education environments within the technical sciences.

AU Engineering is anchored in the university's four engineering departments:

- **Department of Biological and Chemical Engineering**
- **Department of Civil and Architectural Engineering**
- **Department of Electrical and Computer Engineering**
- **Department of Mechanical and Production Engineering**

Here, researchers and students in collaboration with industry, companies, knowledge institutions and authorities from around the world develop innovative and sustainable solutions to the major challenges facing humanity.

CAE

DEPARTMENT OF **CIVIL AND ARCHITECTURAL ENGINEERING**

cae.au.dk

Keywords: Building design and construction, structural engineering, building design, building physics, building production, construction automation and information technologies, fluid dynamics and building ventilation, lean construction, tectonic design, computational methods, structural dynamics and monitoring, wood construction, construction materials, geotechnical engineering, building services engineering, indoor climate and energy, infrastructure, the environment and climate adaptation

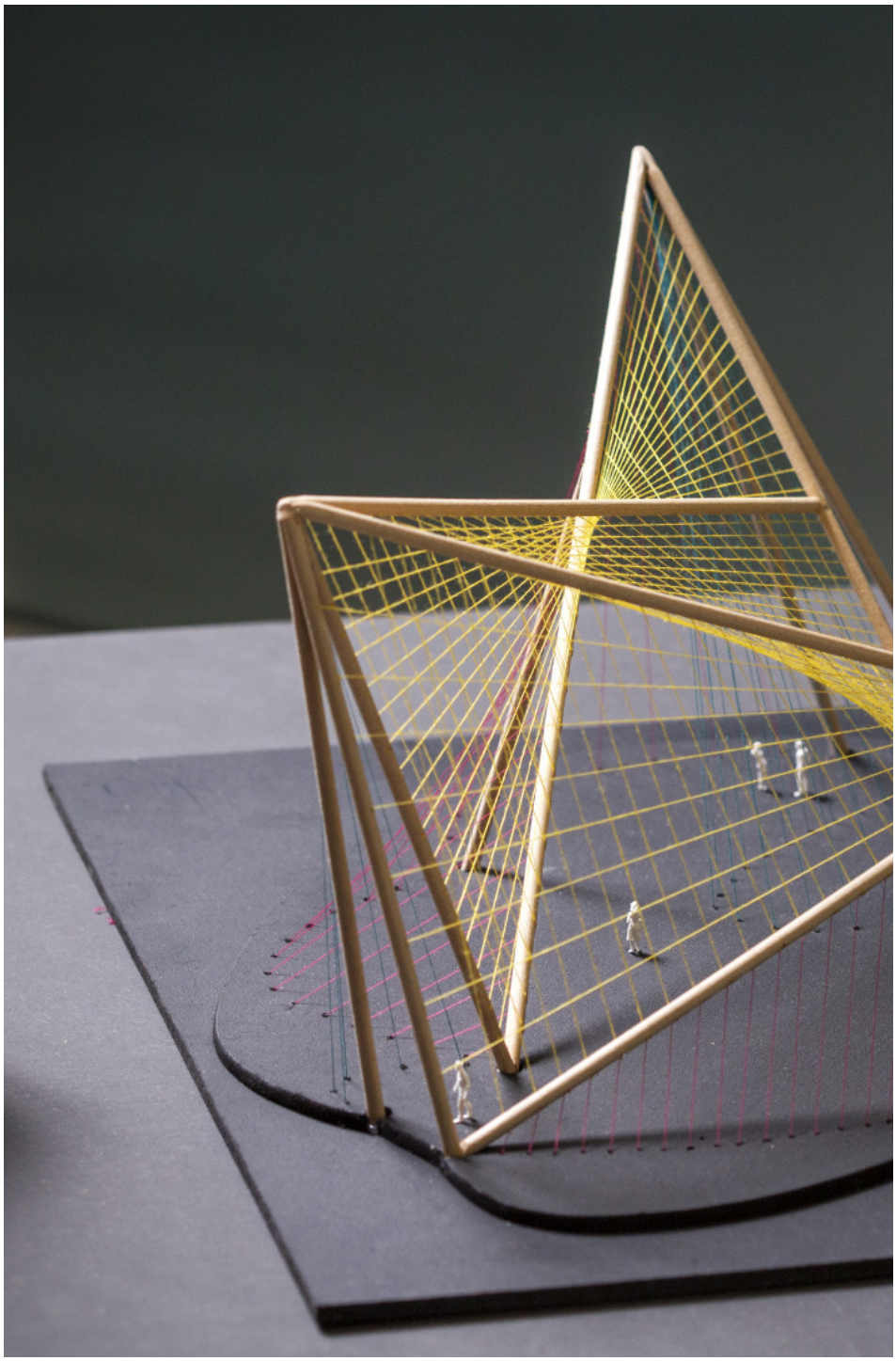


Photo: Lars Kruse, AU Photo

From the exhibition "Connecting Lines: The Tectonics of Ruled Surface Structures" that showcased the results of our research-based MSc course "Tectonics in Engineering and Architectural Design".

CAE

UNIVERSITY CITY LIVING LAB: DEVELOPING NEW DECISION-MAKING TOOLS FOR RENOVATION

Graphics: AART Architects

CAE

A major new international research project aims to develop new decision-making tools for renovation featuring sustainability certification. The tools will be developed and tested directly in the design and construction of Aarhus University's new campus, the University City, which is to be built on the old municipal hospital site.

With outset in Aarhus University's (AU) new campus, the University City, which is to be built over the next five years, AU will form the framework for an international research project to develop new tools for best building renovation practice. This will provide a framework for healthy and highly efficient green buildings.

The project is called PROBONO, and it has received EUR 20.2 million, or approx. DKK 150 million, from the EU Framework Programme for Research and Innovation, Horizon 2020. The project has 47 partners from throughout Europe.

"Aarhus University is thrilled about participating in the project, both as a research institution contributing new engineering knowledge and tools, and by physically running a Living Lab in the project; a large-scale laboratory where, as the base for a major renovation project, we will obtain real-life experience with the tools we develop," says Eskild Holm Nielsen, dean of the Faculty of Technical Sciences at Aarhus University.

The ambition of PROBONO is to develop and test solutions for the design, construction and operation of new and/or renovated Green Building Neighbourhoods (GBN), with a positive energy balance and zero CO_2 emissions. All as part of sustainable, green urban development.

This development will take place in so-called Living Labs (LLs), which the project will establish six of (Madrid, Dublin, Porto, Brussels, Prague and Aarhus). In Aarhus, the project is based on AU's renovation of the municipal hospital, with total floorspace of 143,306 square metres, and the university's principles for sustainable building projects with a healthy indoor climate that supports research and study environments.

"AU is implementing DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen) certification for the University City as an urban area and for the buildings, but AU will also be the driving force for generating evidence and examples of everything from materials and reuse to innovative business models. There are many examples and a lot of research, from renovating schools for example, but there is only very limited research into how a university's indoor and outside areas can create healthier, more efficient and sustainable research and learning environments. We hope to achieve this with this project," says Aliakbar Kamari, assistant professor at the Department of Civil and Architectural Engineering and one of the leaders of the Danish part of the project.

The project will illustrate how innovative, smart technology and digitalisation can be used to benefit society. Among other things, the project will provide a GBN Digital Twin implemented across the LLs as a virtual representation of associated GBNs including operational assets that comply with today's sustainability, emissions and health standards in a lifecycle perspective.

The 47 partners in the project come from 15 different countries. PROBONO (short for the integrator-centric approach for realising innovative energy efficient buildings in connected sustainable green neighbourhoods) will run for a total of five years (2021-2026) and has a total budget of EUR 25.3 million. The Danish partners in the project are VisBlue, COWI, GECO Global and AU.

The Danish part of the project is being carried out by researchers from the Department of Civil and Architectural Engineering and the Department of Electrical and Computer Engineering. Furthermore, researchers from the Department of Environmental Science, AU Centre for Digital Twins (DIGIT) and AU Estates Projects and Development are participating.

The project is being coordinated by Acciona Engineering.

Contact:
Aliakbar Kamari
Assistant Professor
Department of Civil and Architectural Engineering
- Design and Construction

ak@cae.au.dk

CAE

Contact:
Steffen Petersen
Head of section
Department of Civil and
Architectural Engineering
- Design and Construction

stp@cae.au.dk

Energy renovation and building culture

Buildings gobble up energy, and primarily the older building stock is very energy-inefficient. However, renovation is not just about economics and energy, says Associate Professor Steffen Petersen from Aarhus University.

Buildings today are responsible for 40 per cent of total energy consumption in Europe. At the same time, up to 75 per cent of the building stock is energy-inefficient, and up to 85 per cent of it will still be in use in 2050.

This makes buildings one of the global community's biggest energy consumers.

Politically, there is broad consensus that renovation of existing buildings has great potential for energy reductions. In fact, renovating existing buildings is crucial if Denmark is to meet its climate target of reducing carbon emissions by 70 per cent before 2030.

As Associate Professor Steffen Petersen from the Department of Civil and Architectural Engineering at Aarhus University says:

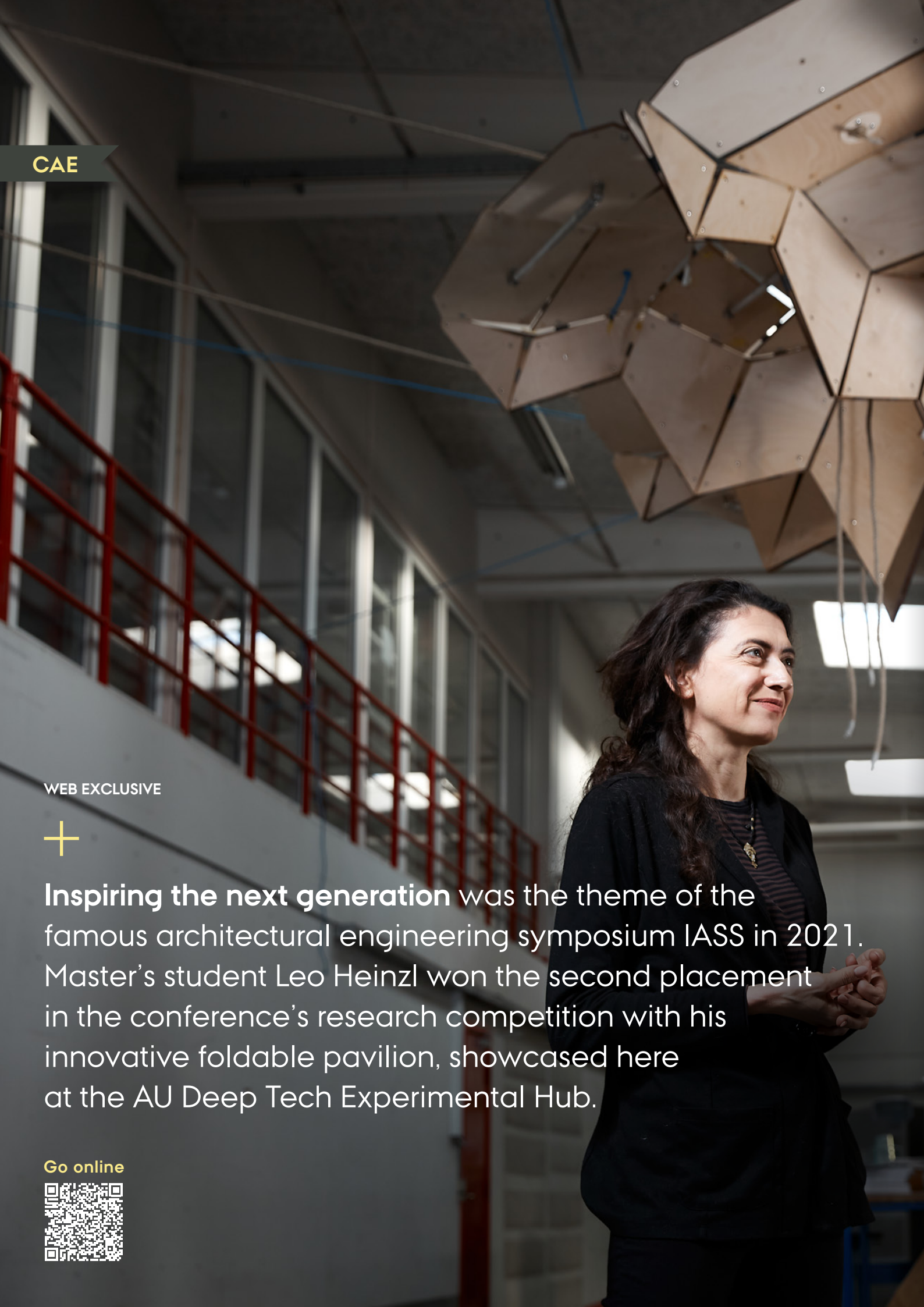
"Is renovating worthwhile, or do we have to demolish and build anew to reach our climate target? This is very case specific, but reducing the CO_2 emission from existing buildings through energy renovation is absolutely vital to meet our climate targets. And when doing so, we must remember to think holistically to come up with integrated solutions that revitalise other aspects of the old buildings," he says.
Research shows that the built environment can be an important element in promoting social relations, improving security, preventing crime, improving human health, and much more.

Moreover, many old and historic buildings are an important part of our self-perception and culture, and can also be an excellent demonstration that durability over time is also an important part of the overall climate balance.

In collaboration with Realdania, Aarhus School of Architecture, MOE A/S and others, in 2021 Aarhus University mapped existing knowledge about lifecycle assessments and conservation values relative to building culture and climate.

The study found that, on the basis of a lifecycle perspective, it is possible to reduce the climate impact of existing buildings to the same level as new buildings and at the same time maintain or strengthen the cultural and cultural-historical qualities of the buildings.

"That's why I'm also looking forward to the experience we'll obtain in the PROBONO project via Living Labs. The development of innovative digital solutions is an important element in achieving significant reductions in the carbon load from existing buildings. New buildings are certainly not the answer to everything, and we can come a long way with renovation," says Steffen Petersen.



WEB EXCLUSIVE

Inspiring the next generation was the theme of the famous architectural engineering symposium IASS in 2021. Master's student Leo Heinzl won the second placement in the conference's research competition with his innovative foldable pavilion, showcased here at the AU Deep Tech Experimental Hub.

Go online

Photo: Marjun Danielsen, AU Photo

Private photo

Hasan is 3D printing a tiny-house in Holstebro

Hasan Alsofi graduated as a civil engineer in January 2021. He has now established a building contractor company called 3DCP with his friend Mikkel. Together with the Municipality of Holstebro, they are building the company's pilot project. Their dream is to become Denmark's first 3D-print contractor and to completely revolutionise the construction industry.

In the centre of Holstebro, a stone's throw away from the train station, a completely new kind of house has seen the light of day. The contractors, 3DCP ApS, are building a prototype 37-square-metre, architect-designed 3D-printed tiny house in collaboration with the Municipality of Holstebro, Saga Space Architects, Bygkontrol ApS and Cobod A/S.

Behind 3DCP are the two student friends, Hasan Alsofi and Mikkel Brich. Both are graduates from Aarhus University, Hasan in civil engineering and Mikkel in law, and they are now about to completely rewrite the rules for one of the world's oldest industries.

"With the help of modern 3D printing technology, we can build better, cheaper, more exciting and sustainable buildings. And we can build them much faster. 3D printing is no doubt a huge milestone for the construction industry and the methods that have been the standard for centuries. And it's fantastic to see the prototype rise up layer by layer, and see our vision become a reality," says Hasan Alsofi.

The two friends founded the company after completing their studies. They "played with the idea of 3D-printed buildings, because we thought it was cool and super efficient," explains Hasan. Mikkel comes from Holstebro and he knew about a vacant building site, so he contacted the municipality, who were immediately ready to join the project:

"The enquiry from 3DCP is a really interesting initiative and it may show us something about the construction methods and living forms of the future. Thanks to the innovative processes in 3D printing, we can build new and sustainable buildings in less time, and this will release time and expertise to refine other processes," says Thomas Leerberg, head of planning at the Municipality of Holstebro.

With 3D-printed houses, you can build faster, greener, cheaper and with greater architectural freedom. The raw house of 37 square metres can actually be built in just eight hours, and this could help to release resources to build better, and focus on a better indoor climate and more sustainable solutions in general.

"It's crucial that we have more green, healthy and sustainable solutions for the building sector," says Kasper Lynge, deputy head of department at the Department of Civil and Architectural Engineering at Aarhus University.

Today, buildings account for approx. 40 per cent of Denmark's total energy consumption, 65 per cent of buildings were built before 1980, when there were no real requirements for energy consumption and indoor climate, and producing materials for the construction industry is one of the world's largest contributors to climate change.

CAE

Contact:
Hasan Alsofi
3DCP ApS
Tel.: 2197 1308

ha@3dcp.dk

"We're looking into the future with this pilot project," says Kasper Lynge. "Automation and digitalisation are becoming increasingly important in construction for several reasons. Firstly, we can build faster and cheaper and with completely new shapes than previously, and secondly, we can minimise waste and use fewer materials. "

He continues:

"Right now, we use concrete, but in the long term, with 3D printing, we'll be able to start looking at other materials such as clay. We look forward to following the project and finding out more. We need people like Hasan and Mikkel, who just throw themselves into it. This is how we can develop the construction industry."

The Department of Civil and Architectural Engineering is supporting the project through knowledge collaboration. When the prototype is complete, the plan is for the university to carry out measurements in the building and to incorporate this knowledge into engineering programmes.

The plan is to build prototype tiny houses on the site in Holstebro. However, the local authority would like to go further than just prototypes, and Thomas Leerberg says that he expects the municipality to have 3D-printed tiny houses ready for habitation soon, if everything goes well.

Photo: 3DCP ApS

Fully printed house. The raw house of 37 square metres can actually be built in just eight hours, and this could help to release resources to build better, and focus on a better indoor climate and more sustainable solutions in general.

CAE

Contact:
Kasper Lynge
Deputy Head of Department
Department of Civil and
Architectural Engineering

kl@cae.au.dk

Why experimental construction is the way forward

That the company 3DCP embarked on a 3D-printed building in Holstebro is not merely interesting. It is a potential revolution for the construction industry, because it is an excellent way for the industry and knowledge institutions to work together, says Kasper Lynge, deputy head of department at the Department of Civil and Architectural Engineering.

It is not often that something shakes to the core the world's probably oldest industry, the building industry, but 3D printing could do just that. The technology is advancing in leaps and bounds, and many interesting projects are already being realised all over the world.

Denmark's first 3D-printed house was built in Holstebro in 2021-22. Two newly qualified graduates from Aarhus University, Mikkel Brich and Hasan Alsofi, were behind the achievement, and they founded the company 3DCP.

"They're passionate in the true sense of the word, and that's exactly what we need. Because experimental buildings like this can really take us forward as an industry - and people like this can take the lead, show the way ahead and demonstrate that it is actually possible for a new technology to have a major impact on how we build," says Kasper Lynge, deputy head of department at the Department of Civil and Architectural Engineering at Aarhus University.

3D printing is a major part of an ever-expanding digitalisation and automation of the construction sector. And there's no getting away from the benefits: faster construction, lower costs, opportunities to build more complex structures, more focus on function and less waste generation.

But we must remember that the technology is still in its infancy. As a result, according to Kasper Lynge, there are many construction-technical aspects to be improved in the 3D printing technology, so that it can be integrated and optimised in relation to current rules and standards for indoor climate, energy consumption and air leakage.

And because of this, it is also quite alright today for structures to be 3D-printed in high-strength concrete, for example.

"Right now, we need to get to know the technology. It has to be developed and streamlined before we can develop the materials we print with. That's why it's important that universities get involved in these projects to help test, measure, weigh and document and target our research and development to optimise this technology, which is so important for future construction," he says.

He continues:

"I hope that we can get more collaboration across disciplines and the sector. Let's meet where construction is actually taking place. I'm sure we can help each other much more, and experimental buildings like the one 3DCP is working on are an excellent mouthpiece for fusing together regulations, standards, innovation and research."


DURAN
DURAN

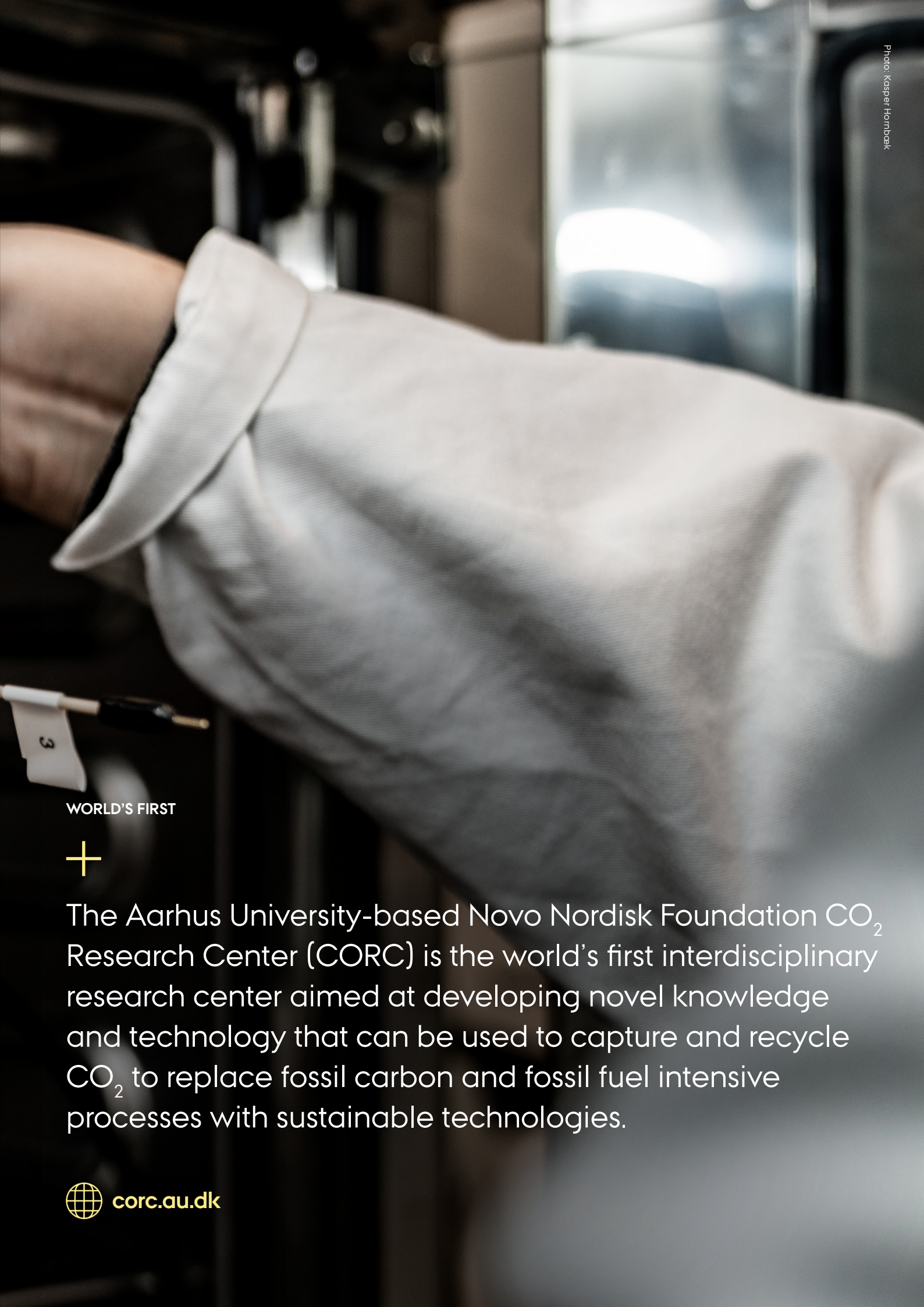


Photo: Kasper Hornbæk

WORLD'S FIRST

The Aarhus University-based Novo Nordisk Foundation CO_2 Research Center (CORC) is the world's first interdisciplinary research center aimed at developing novel knowledge and technology that can be used to capture and recycle CO_2 to replace fossil carbon and fossil fuel intensive processes with sustainable technologies.

corc.au.dk

Photo: Søren Kjeldgaard

Aarhus University park.

BE INSPIRED +

The engineering departments at Aarhus University cooperate with a wide range of organisations, companies and authorities on research and development projects. As this magazine illustrates, we establish partnerships with businesses of all sizes and languages to help build and develop new products and services, to explore innovative trend-setting technology for real-world applications, and to process-optimise production and value chains.

Are you interested in working with the region's leading knowledge institution? We offer a range of cooperation models from student projects and internships to R&D projects involving world leading engineers and scientists:

- **Commissioned research**
- **Co-financed research collaborations**
- **Co-financed innovation and development projects**
- **Industrial and company PhD programmes**
- **Industrial and company Postdocs**
- **Engineering internships**
- **Bachelor projects and Master's theses**
- **Local public-private partnerships**
- **Interdisciplinary research centres**
- **High tech research labs and experimental facilities**
- **Applied innovation in Engineering: a company case-based compulsory programme for engineering Masters' students**

Contact us directly for more information on collaboration, see below.

GET INVOLVED
Tap into the latest research and technological knowledge within engineering sciences to gain valuable insight into the technologies that are most relevant for you, your challenges and your industry.

Aarhus University is active in almost every business cluster in Denmark, and in many other scientific, technical and innovation-related networks. We can help introduce your business to local and international networks – an excellent way to profile your company, solve your challenges in collaboration with others, and develop long-term strategic partnerships with other companies or knowledge institutions.

WORK WITH US
If you would like to explore the opportunities of working with us, don't hesitate to contact us directly for further information. Find your corresponding point of contact below. Or just call us, and we'll guide you through.

CAE
Civil and Architectural Engineering
Kasper Lynge kl@cae.au.dk
Keld Laursen kela@cae.au.dk

BCE
Biological and Chemical Engineering
Uffe Sognstrup Thomsen ust@bce.au.dk
Keld Lars Bak klb@bce.au.dk

ECE
Electrical and Computer Engineering
Andy Drysdale adr@ece.au.dk
Kasper Løvborg Jensen leafcastle@ece.au.dk

MPE
Mechanical and Production Engineering
Steen Nielsen sni@eng.au.dk
Anders Brandt abra@mpe.au.dk

BCE

DEPARTMENT OF BIOLOGICAL AND CHEMICAL ENGINEERING

bce.au.dk

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

Photo: Anders Trærup

Biomass turned to biocrude at the university's research center in Foulum.

BCE

CELINE'S BACHELOR'S PROJECT WAS THE CORNERSTONE IN A NEW WASTE-SEPARATION TECHNOLOGY

Photo: Anders Trærup

Photo: Anders Trærup

It is important to remember the energy and wild ideas of the young engineering students, says the plastic separation company Plastix, who speak warmly about Celine Ballegaard Karlsen and her Bachelor's project which was part of the Re-Plast research project (p. 36)

"There must be some mistake," said Celine as she sat in front of her Mac in her small one-bedroom student apartment in Aarhus in early October last year.

She had gathered a vast amount of spectrum data using Aarhus University's new hyperspectral camera, which had taken a number of images of different types of plastic on an assembly line, and now she had run all the data through a primary component analysis (PCA).

"The images show the light waves captured by the hyperspectral camera when the plastic samples are illuminated. A spectrographic analysis of these gives me a whole lot of curves on a graph. I sat and looked at the curves, but I simply couldn't see any difference between them, so I tried to see a difference using a PCA analysis," says Celine about her experiments.

And apparently, she could. Because the result she received was, to put it mildly, surprising.

Plastic, polymers, and recycling

Celine Ballegaard Karlsen was born and grew up in the Danish town of Grenå. She comes from a very traditional family and is the eldest of five sisters.

Celine is dyslectic and she has been really bad at language subjects all her life. She can read well enough, but it takes a long time, and so today she gets the computer to read for her.

At primary school, she was very good at maths, but when the alphabet took over, things became more difficult for her. But she is practical and logical, and she has always liked science subjects, so she chose maths, physics and chemistry as her main subject line at upper secondary school. She also likes technology: a hobby she mentions that she inherited from her father, who is a molecular biologist.

The idea of the chemical engineering programme came to her quite early on, and she started on the Bachelor of Engineering programme in chemistry at Aarhus University in the summer of 2017.

On the fourth semester she had a course about polymers, and she found this very interesting.

"It wasn't as process-technical as many of the other courses, and I liked that. And I met Associate Professor Mogens Hinge, who said that I could do my Bachelor's project with him if I liked," she says.

She continues,

"Plastic, polymers and recycling is an incredibly exciting area. We're living at a time when we throw out huge amounts of plastic that we can't recycle. In fact, we can only separate a small fraction for reuse, and I think it's a shame that all these resources are just being incinerated. So it would be fantastic if I could contribute to something that might make a difference in the area."

An important resource

This way of thinking struck a ray of hope for the future for Hans Axel Kristensen, CEO of the Lemvig-based cleantech company PLASTIX.

The company converts used fishing tackle into raw materials for plastics by washing, drying and melting plastic fibres from old fishing nets and rope, for example, into plastic granulate that can then be reused in new plastic.

"We're delighted with our research collaboration with Aarhus University, and it's been a real pleasure to see the extent to which engineering students have contributed to the project. It's important to remember the energy and wild ideas of the young that exist

Photo: Anders Trærup

"We're living at a time when we throw out masses of plastic that we can't recycle. In fact, we can only separate a small fraction for reuse, and I think it's a shame that all these resources are just being incinerated," says Celine Ballegaard Karlsen.

among engineering students. They're passionate, and it's often students who create new synergies and set things in motion. They're an important resource at every step of their education and they help to make important breakthroughs, like we've seen here," says Hans Axel Kristensen.

He remembers very well the autumn of 2020, when Celine and researchers from Aarhus University presented the very exciting results of the Re-Plast project, and when it became clear to him and the rest of the team that they were on the verge of something entirely new in plastic separation.

"The technology we've developed in collaboration with the university is nothing short of a breakthrough for our ability to recycle plastics," he says.

Learning about everything around us

Today, Celine is 24 years old and she is studying for an MSc in Engineering in Chemical Engineering and Biotechnology at Aarhus University's Department of Biological and Chemical Engineering. She is working on her Master's thesis on agricultural plastics with her supervisor, Mogens Hinge.

In her apartment at the "Dania" halls of residence there are two pictures, one showing the molecular structure of coffee and the other the molecular structure of chocolate. The pictures are almost identical, and they remind her that even minor changes in the building blocks of things can have enormous significance.

This also applies for plastics, which are often made up of chains of carbon and hydrogen atoms linked together in different ways.

"That's really what makes chemistry so exciting. Learning about everything around us. Learning that everything is basically put together with the same building blocks, the same atoms, but in different ways so that things have very different applications," she says.

It is these tiny differences that the new camera technology can distinguish between. So far, the team behind the Re-Plast project now knows the difference between 12 different types of plastics, which together constitute virtually all household plastics and a number of high-performing plastics. But the research is not over yet. The project will continue, and before long the project partners expect to be able to differentiate further between types of polymer and various additives.

Celine's Bachelor's project has been a significant scientific contribution to the article published by the team in the international journal Vibrational Spectroscopy and it has had a major impact on the experimental development of the methods to be implemented at industrial scale in 2022.

She is very pleased that her project ended as it did, even though it meant that she had far more work:

"The project was huge compared with the just 20 ECTS credits it had to fill," she says, and continues:

"But it's been very satisfactory. When I started, I had an idea that this might be realised in the real world at some time far in the future. I thought that the kind of research we're doing at university wouldn't be realised for many years. So, I'm very pleased that we can already start using the technology in industry. It's been great to work with, and I'm proud of my contribution to solving this huge challenge."

Photo: Anders Trærup

Old fishing nets and rope piled up at the Lemvig-based cleantech company PLASTIX.

BCE

The Re-Plast project is a breakthrough in separating plastic waste

For the first time, we can now tell the difference between a wide range of plastic types and thereby separate plastics according to their chemical composition. This is absolutely ground-breaking and it will increase the rate of recycling of plastics immensely. The technology has already been tested at pilot scale and it will be implemented at an industrial scale in spring 2022.

In contrast to common perceptions, plastic is in no way near one material. Rather, it is a combination of many materials (polymers) with different chemical compounds and additives such as pigments or fibres, depending on its use. It is very difficult to tell the difference between different types of plastics, and this is what makes it difficult to separate and recycle them.

In collaboration with Vestforbrænding, Dansk Affaldsminimering Aps, and PLASTIX, researchers from the Department of Biological and Chemical Engineering at Aarhus University have now developed a new camera technology that can see the difference between 12 different types of plastics (PE, PP, PET, PS, PVC, PVDF, POM, PEEK, ABS, PMMA, PC, and PA12). Together, these constitute the vast majority of household plastic types.

The technology makes it possible to separate plastics based on a purer chemical composition than is possible today, and this opens up for completely new opportunities to recycle plastics. The technology has been tested at pilot scale and is planned to be implemented at PLASTIX and Dansk Affaldsminimering Aps in 2022.

"With this technology, we can now see the difference between all types of consumer plastics and several high-performance plastics. We can even see the difference between plastics that consist of the same chemical building blocks, but which are structured slightly differently. We use a hyperspectral camera in the infrared area, and machine learning to analyse and categorise the type of plastic directly on the conveyor belt. The plastic can then be separated into different types. It's a breakthrough that will have a huge impact on all plastics separation," says Associate Professor Mogens Hinge, who is heading the project at Aarhus University.

The study has been published in the scientific journal *Vibrational Spectroscopy.*

Plastics are currently separated using near-infrared technology (NIR) or via density tests (floats/sinks in water).

Contact:
Mogens Hinge
Associate Professor
Department of Biological and Chemical Engineering
- Process and Materials Engineering

hinge@bce.au.dk

Contact:
Hans Axel Kristensen
CEO
PLASTIX A/S
Tel.: 2326 5090

hans@plastixglobal.com

These methods can separate certain plastic fractions (for example PE, PP, and PET), but not with the same accuracy as the new technology, and therefore not with the chemical purity in the composition, and this is vital to be able to increase the recycling rate of waste plastic.

"The technology we've developed in collaboration with the university is nothing short of a breakthrough for our ability to recycle plastics. We look forward to installing the technology in our processing hall and starting in earnest on the long journey towards 100% utilisation of waste plastic," says Hans Axel Kristensen, CEO of PLASTIX.

Plastic must be at least 96% pure by polymer type to be recycled in conventional industry. This means that the plastic has to be separated to an almost pure product in terms of chemical composition.

Using the new technology, we are now a big step along the way, says Associate Professor Mogens Hinge, who stresses that the technology is continuously being developed and that data indicates it may be possible to differentiate even further between polymer types and additives before long.

The hyper-spectral camera technology has been developed in cross-disciplinary collaboration, including BSc and MSc engineering students and researchers at the Department of Biological and Chemical Engineering at Aarhus University, as well as experts from the participating companies.

The research is part of the Re-Plast project, which is being funded by the Innovation Fund Denmark with DKK 22.7 million. The project is being headed by the Department of Biological and Chemical Engineering at Aarhus University. Other participants are the Department of Electrical and Computer Engineering at Aarhus University, Vestforbrænding, Dansk Affaldsminimering and PLASTIX.

Photo: Anders Trærup

BCE

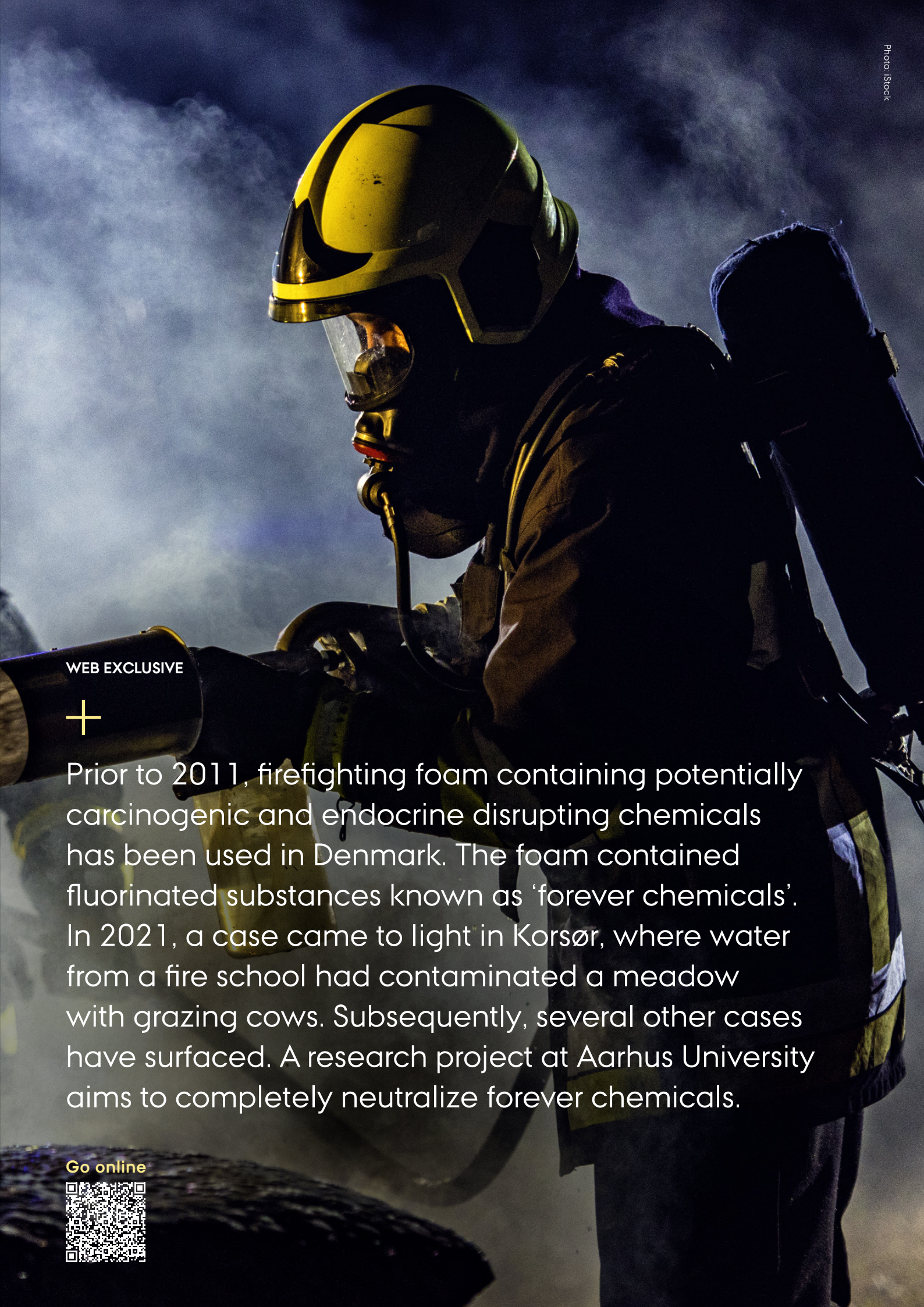


Photo: iStock

WEB EXCLUSIVE

+

Prior to 2011, firefighting foam containing potentially carcinogenic and endocrine disrupting chemicals has been used in Denmark. The foam contained fluorinated substances known as ‘forever chemicals’. In 2021, a case came to light in Korsør, where water from a fire school had contaminated a meadow with grazing cows. Subsequently, several other cases have surfaced. A research project at Aarhus University aims to completely neutralize forever chemicals.

Go online

BCE

New demonstration plant at AU Viborg in Foulum may significantly reduce carbon emissions from methanol production

In collaboration with Haldor Topsøe, Aarhus University has launched a new demonstration plant to produce sustainable methanol from biogas. The plant opens up for significant global potentials to reduce carbon emissions from methanol production.

Each year, around 110 million tonnes of methanol are produced. Production is based almost exclusively on fossil fuels and therefore it emits significant quantities of CO_2 – for each tonne of methanol produced, approx. 1.4 tonnes of CO_2 are emitted.

Now, in collaboration with Haldor Topsøe, the Technical University of Denmark, Aalborg University and others, researchers from the Department of Chemical Engineering and Biotechnology have set-up a new demonstration plant with potential to turn classical methanol production completely on its head.

The new plant can produce methanol exclusively from biogas and renewable energy. The project is funded with DKK 38 million from the Energy Technology Development and Demonstration Program (EUDP).

"We're delighted with the results of the project so far. The system demonstrates a new electrical methane reforming technology (eSMR) that is crucial in a future based on renewable energy and the circular bioeconomy," says Thomas Lundgaard, the project manager at the Department of Chemical Engineering and Biotechnology at Aarhus University.

He continues:

"The demo plant fits perfectly into our energy research plant at Foulum, and we're looking forward to pursue the potential for further development and integrating the technology into the energy system of the future."

Kim Grøn Knudsen, Chief Strategy and Innovation Officer at Haldor Topsøe, says about the project:

"With this initiative, we will demonstrate that we are able to transform classical production process into a fully carbon-neutral scheme. Specifically, we will demonstrate that sustainable methanol can be produced from biogas at a very competitive cost compared to other green methanol produced from non-fossil fuels."

Methanol is an organic compound classified as an alcohol, and it is used for a wide variety of purposes. Among other things as a fuel and solvent, and as an extremely important platform chemical in the production of a wide range of other chemicals.

Currently, the liquid is usually synthesized from fossil natural gas. Methane is split into hydrogen and carbon monoxide by adding a quantity of the gas as energy input. The whole process is dependent on fossil fuels and energy sources, and this is where the new plant will change things dramatically.

The eSMR technology splits biogas using an electrically driven catalyst and with an energy supplement from hydrogen produced using electrolysis technology. By using renewable energy from wind and the sun, as well as biogas extracted from slurry and sewage sludge, for example, the technology can transform biogas into methanol through a completely sustainable process.

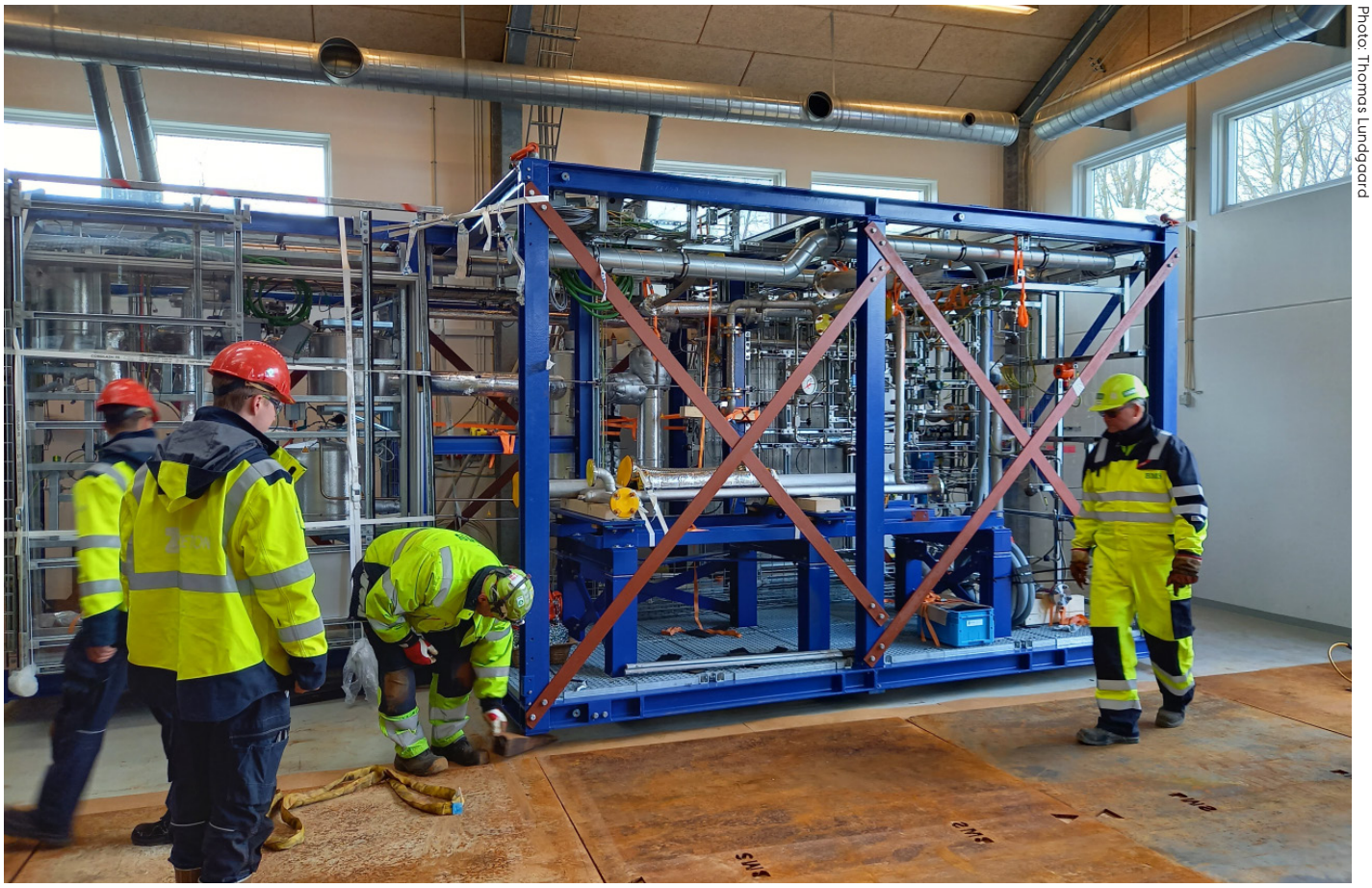


Photo: Thomas Lundgaard

The new demo plant being installed at research center Foulum.

The project is being managed by Haldor Topsøe, and the project partners are Sintex A/S, Blue World Technologies, the Technical University of Denmark, Energinet A/S, Aalborg University, PlanEnergi and the Department of Chemical Engineering and Biotechnology at Aarhus University.

The plant has an annual capacity of 100,000 litres of carbon-neutral methanol from biogas and green power, and it is planned to be fully operational in early 2022.

POWER-TO-X

In a world powered by green energy sources, there's an essential need to store energy for periods without sun and wind. There is also a need for fuels and chemicals for the parts of industry and infrastructure where fossil resources cannot immediately be replaced by renewable electricity.

This is where Power-to-X comes into play. Using excess electricity from renewable sources, the technology converts this power into carbon-neutral fuels or chemicals (i.e. methanol), which can readily and easily be stored and used the same way as fossil resources – for instance directly as drop-in fuels for ships, heavy traffic and aircraft or as platform chemicals in the chemical industry.

Power-to-X is a crucial element in the green transition and a vital piece in the concept of circular bioeconomy, where nothing goes to waste, where no fossil fuels are dug out of the ground, and where there is a sustainable alternative for everything, we dig up today.

Contact:
Thomas Lundgaard
Special Consultant
Department of Biological and Chemical Engineering
- Process and Materials Engineering

thomas.lundgaard@bce.au.dk

AU IN SPACE

The Aarhus Space Centre, SpaCe, is the university's centre for inter-disciplinary space activities and a facilitator for collaboration between space research and innovation and the Danish space industry. The center officially started operations on 1 January 2022.

space.au.dk

The Aarhus University satellite Delphini-1 was deployed from the International Space Station in 2019.

Photo: NASA

An important interplay

Every year, Aarhus University sends more than 700 engineering interns into the business community with knowledge about existing and emerging technologies, sustainability and digitalisation. This is a stable and targeted form of tech transfer, and it is crucial both in the individual company and for productivity development in Denmark.

Danish companies are increasingly basing their core business on technology and digital solutions. At the same time, they are in the midst of global competition, where access to knowledge and well-qualified labour determines their potential for growth.

This presents new opportunities for the interplay between the university and the business community, and engineering interns can play an important role in this context.

"We must transfer knowledge created at the university to benefit society and especially to benefit private and public-sector companies," says Kurt Nielsen, vice-dean for business collaboration and public-sector consultancy at the Faculty of Technical Sciences at Aarhus University.

He mentions increasing demand for interns from companies throughout Denmark and continues:

"We're experiencing very high interest for interns from many different companies, showing that advanced technology businesses need close links to innovation and research environments. A one-semester collaboration can initiate a long-term partnership, even with small companies without a tradition for innovation, as they can get new in-house competences."

Testing ideas close to risk-free

The Danish tech company, ReMoni, manufactures sensors to monitor resource consumption in buildings and production systems, and every year the company asks for engineering interns from Aarhus University.

The interns are involved in various project teams and contribute to development activities.

"They generally come to us with a high level of knowledge. This means that we can use them to develop solutions to many different issues. But we also use the interns to test possibilities in the early stages of an innovation process without having to invest too many resources. This is very valuable for us," says Bo Eskerod Madsen, CEO at ReMoni.

An open-door university

Behind the yellow walls at Aarhus University, work is always underway to create a good match between interns and companies. All Bachelor of Engineering programmes have internship coordinators with an open door to business and industry.

"For us, the interns are a unique opportunity to reach out to different types of companies in many different sectors, which we might otherwise never get in contact with," says Kurt Nielsen.

An internship agreement can often be the first step in a long-term collaboration, which can also include Bachelor's and Master's projects and perhaps develop into joint research and innovation projects. The vice-dean stresses that there are mutual benefits from having interns in companies for half a year.

"We get a lot in return. Both internships and project collaboration are extremely important for our students. Through an internship, students get valuable experience that helps them to professionalize their work and also gives them insight into their future work life. Aarhus University benefits from having a very large interface with the business community and insight into the trends and challenges faced by companies," he says.

Contact:
Kurt Nielsen
Vice-Dean
Faculty of Technical Sciences

kni@au.dk

Photo: Anders Trærup

Frederik Linding Povlsen is an intern at Bang & Olufsen in Struer. He is working to optimise the chemical process that makes it possible to colour aluminium for the company's iconic products.

Photo: Lars Kruse, AU Photo

During her engineering education, Sandra Maria Sørensen was an intern in the incubation department at Arla Foods Amba on a project called Aurena. She was part of a small team working on product development to help people sleep better.

MPE

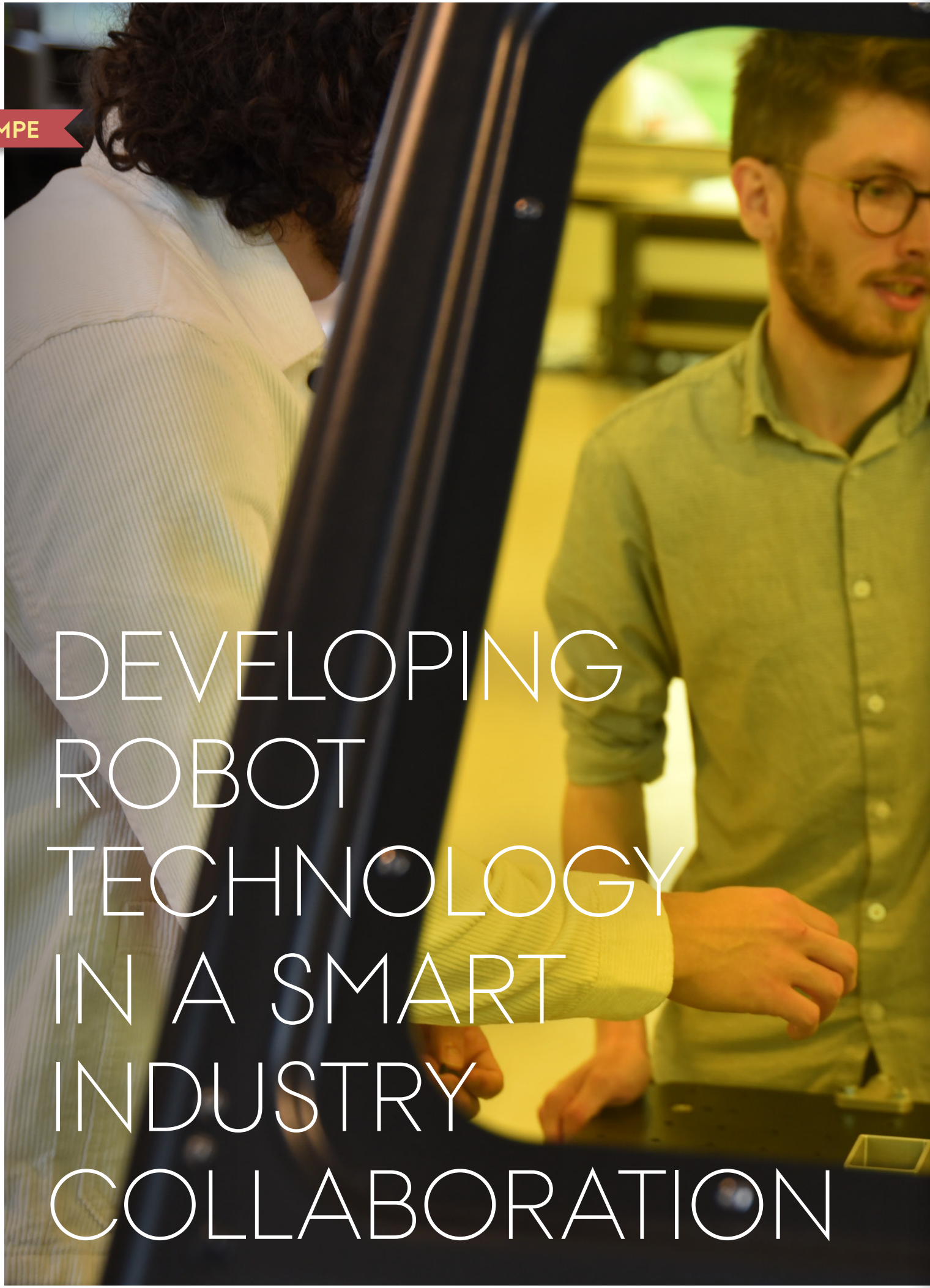
DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

mpe.au.dk

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

Photo: Claus Melvad

The underwater robot North Rov 3D scanning an iceberg below the Arctic Ocean surface.



DEVELOPING ROBOT TECHNOLOGY IN A SMART INDUSTRY COLLABORATION

Photo: Jesper Bruun

MPE

Increasing demand for automation meant that the Danish company, NIZE equipment ApS, was losing customers. Now, in collaboration with engineering students and researchers from AU, the company has started work on developing robots to work with humans in the future.

NIZE equipment supplies large-scale graphics machinery throughout Scandinavia, and the company has won an award for the speed of its growth. In collaboration with engineering researchers at Aarhus University, the company has initiated development of collaborative robot technology for the graphics industry.

The project is part of Smart Industry, an Industry 4.0 development programme funded by the EU Regional Development Fund to help small and medium-sized Danish companies to embrace robot technology, digitalisation and automation.

"There's ever greater demand for machines that can increase efficiency and automate repetitive processes by using robot technology. But unfortunately, there's no plug-and-play, off-the-shelf products to help a company get started on the transition. So what's the answer? Where do you go?" asks Lars Nikolajsen, CEO and founder of NIZE equipment.

He asked himself the same questions back in 2013, when he was losing customers to another supplier because of automation. Finding no answers he could use, he tried himself to develop robot technology that could be integrated into the company's existing printer systems.

"Having robots in production is a huge advantage. For example, you can keep production running outside normal opening hours, or let the robot take over work for an employee who is more useful elsewhere in the production chain. As a supplier, I had to familiarise myself with what robot technology can do, and its strengths and advantages, because that's the future," he says.

SME's have joined the robot wave

In 2019, NIZE equipment joined the Smart Industry project, and since then, engineering students and researchers from AU Engineering have worked with the company's technicians to develop and fine tune collaborative robots that can work with humans on existing printing systems.

"A lot of different small and medium-sized enterprises (SMEs) produce many different products and have dynamic production layouts, so it's very difficult to develop a robotic system with a commercial grabbing device that can handle the multitude of different products. This is one of the reasons why integrating robotic technology into production chains is still a complex task," says Associate Professor Xuping Zhang, an expert in collaborative robots at the Department of Mechanical and Production Engineering at Aarhus University, who is in charge of the project.

He continues:

"Many Danish SMEs have yet to join the robot wave, even though the same companies are increasingly worried about losing their competitive edge to foreign companies. But fortunately, it's actually quite easy to set up a collaboration with us," he says.

Valuable technology

For Lars Nikolajsen, the collaboration with Aarhus University has been a great success. The collaborative robot system has not yet been fully developed, but the company has gained valuable insight into what is needed to make the technology work, and they can now begin to see a product take shape.

"There's still some way to go before we have a finished product for commercialisation, but we've identified a lot of technical aspects of automation that we can take further. We'd never have got here without our collaboration with the university, because we simply can't afford to hire a group of software engineers to develop something like this," he says.

The Smart Industry development programme was completed in 2021, but both the researchers and the company hope to continue their collaboration.

"Our customers are increasingly asking for automation, and this applies for many sectors. We need much greater focus on digitalisation and robot technology if we in the small Scandinavian countries are to survive in the future. So, I hope that we'll be able to continue our collaboration and develop more of the technology society is looking for," says Lars Nikolajsen.

Contact:
Xuping Zhang
Head of Section
Department of Mechanical
and Production Engineering
- Mechatronics and Dynamics

xuzh@mpe.au.dk

Contact:
Lars Nikolajsen
NIZE equipment ApS
Tel.: 6914 8990

lars@nizeequipment.dk

NIZE

NIZE equipment ApS is a medium-sized mid-Jutland company located in the town of Odder. The company has 17 employees and is active in Denmark, Norway, Sweden and Finland.

The company was founded by Lars Nikolajsen in 2008, and in 2013 the company began to develop robot technology for one of its printing systems. The project attracted the supplier, who took it on and is now offering a complete robot-assisted system.

In collaboration with the Robotics research team led by Associate Professor Xuping Zhang at the Department of Mechanical and Production Engineering at Aarhus University, NIZE equipment started a project in the Smart Industry framework in 2019 to develop a more intelligent robot system that can perform quality control, take over manual tasks and clean products.

Smart Industry is an Industry 4.0 development programme run by the Central Denmark Region with focus on innovation-collaboration and knowledge sharing, whereby researchers from the university share knowledge with companies in order to optimise processes and incorporate new technology. Companies in the project only invest in the working hours spent on the programme, which is being funded by the EU Regional Development Fund and the Central Denmark Region.

Photo: Jesper Bruun

In 2019, NIZE equipment joined the project, and since then, engineering students and researchers have worked with the company's technicians to develop and fine tune robots that can work with humans on existing systems.

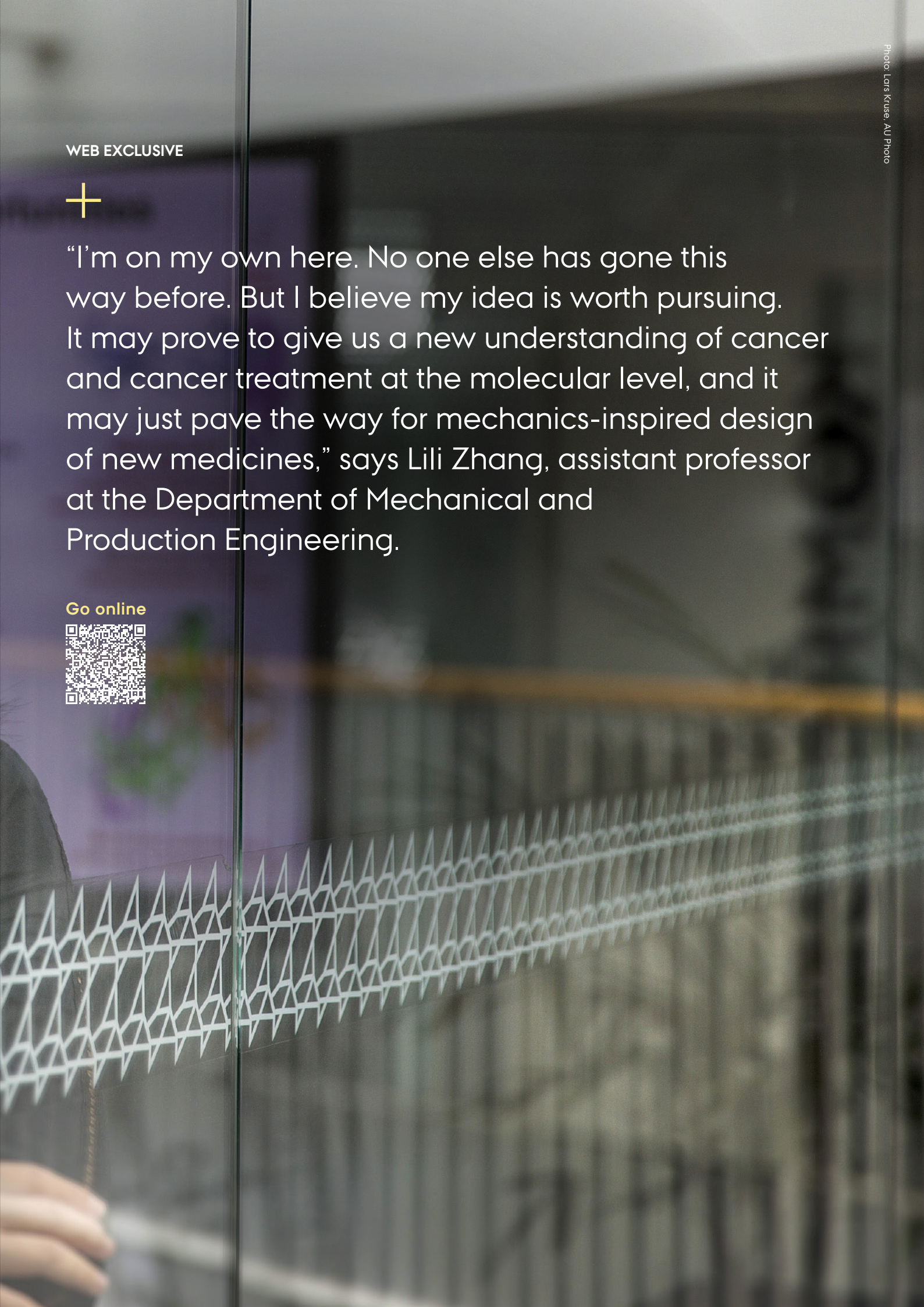


Photo: Lars Kruse, AU Photo

WEB EXCLUSIVE

“I’m on my own here. No one else has gone this way before. But I believe my idea is worth pursuing. It may prove to give us a new understanding of cancer and cancer treatment at the molecular level, and it may just pave the way for mechanics-inspired design of new medicines,” says Lili Zhang, assistant professor at the Department of Mechanical and Production Engineering.

Go online

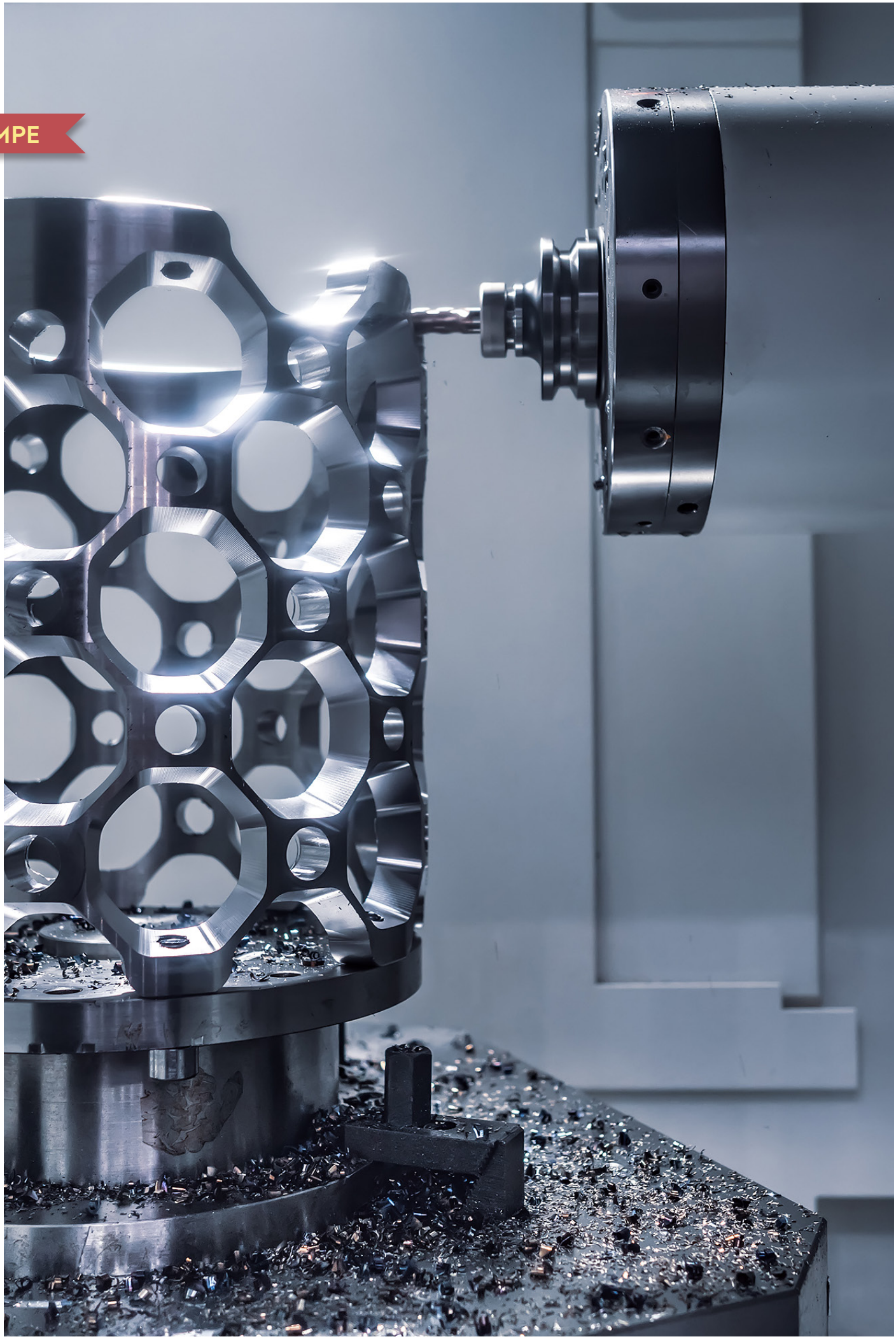


Photo: Colourbox

Worn-out industrial milling tools and damaged materials cost the manufacturing industry billions each year. Now, researchers have developed a model that can predict the mechanism for chip formation and its transition for almost every material. The model reveals the existence of a critical cutting depth as a function of material properties, tool geometry and running conditions. The model is ready for industrial use and to design optimal cutting tools.

A longstanding mystery in manufacturing has been solved

MPE

Contact:
Ramin Aghababaei
Head of Section
Department of Mechanical and
Production Engineering
- Mechanics and Materials

ra@mpe.au.dk

A common aspect of most manufacturing processes is to shape components by removing chips from materials surface. Now, researchers from Aarhus University have experimented to find the perfect cutting process.

Worn-out industrial milling tools and damaged materials cost the manufacturing industry billions each year.

In manufacturing processes, components are shaped by removing chips from a bulk material, but a clear understanding of what factors control the size and shape of removed chips has remained elusive, limiting the manufacturing sector to incremental advancement based on trial-and-error approaches.

Making a perfect cut every time is desirable, and now researchers at Aarhus University have modelled and experimented their way to solve the long-standing challenge of finding a perfect cutting process that minimises tool wear and optimizes surface finish.

"We have developed a simple analytical model that can predict the mechanism for chip formation and its transition for almost every material. The model reveals the existence of a critical cutting depth as a function of material properties, tool geometry and running conditions," says Associate Professor Ramin Aghababaei who's leading the project at Aarhus University.

The study has been published in the scientific journal Physical Review Letters and the research is part of the project Cutting-Edge.

Ramin Aghababaei continues:

"By testing on various plastic materials, we have found a critical cutting depth, below which we can remove long chips in a smooth and gradual way and above which short and irregularly-shaped chips formed in an abrupt manner."

The associate professor points out that deviation from this critical cutting depth has a major impact on wear and tear of the tools used, on energy consumption, and on the final product finish.

"We will continue to develop the model, but tool industries can start using it already to design optimal cutting tools," he says.

The research forms part of the Grand Solutions project, Cutting-Edge, which aims to improve the performance of cutting tools for stainless steel processing. The project is funded by the Innovation Fund Denmark with 7 MDKK.

The publication is a result of a collaboration with Assistant Professor Mohammad Malekan from the University of Southern Denmark and Associate Professor Michal Budzik from Aarhus University.

MPE

“It’s vital that we work together to keep Denmark competitive.”

More Danish companies and knowledge institutions have to collaborate if we are to maintain momentum for Danish competitiveness. This is the message from the DAMRC and others who are calling out for more research and development.

There is an urgent need for the next generation of milling tools for manufacturing, because the useful lifetimes of today’s tools are too short and this is very costly for industrial enterprises.

For this reason, the Danish Advanced Manufacturing Research Center (DAMRC) is working with Danish and foreign universities and companies to maintain the competitiveness of Denmark.

“Denmark is very talented, but costs are high. If we are not constantly at the forefront, we will lose touch. That’s why it’s important that we work together across universities and industry to generate new knowledge on current issues, and to make sure that this knowledge is implemented in real life,” says Charlotte Frølund Ilvig, senior project manager at the DAMRC.

Throughout the world, machines, tools and software are being developed for machining metal, wood and plastics. For example, a lot of work is put into developing the next generation of efficient and durable milling tools by, among other things, developing surface coatings, adapting machining parameters and optimising tool geometry.

And this development is absolutely crucial, adds Torben Nielsen, CEO of TN Værktøjsslibning, a manufacturer of both special and standard tools for processing different materials.

“If the milling tool is not completely up-to-date, companies cannot use their machines properly. This means that they cannot optimise their production: they have too much consumption and too little productivity. If you don’t use your energies to develop these things, then you won’t be here in two years’ time. You’ll be out-competed. Major manufacturers around the world are moving fast, competition is brutal, and so it’s vital that we work together to keep Denmark competitive,” he says.

According to Charlotte Frølund Ilvig, many large Danish companies are already collaborating with universities and knowledge centres on developing new knowledge. However, there is still a large potential – especially amongst the small and medium sized companies (SMEs).

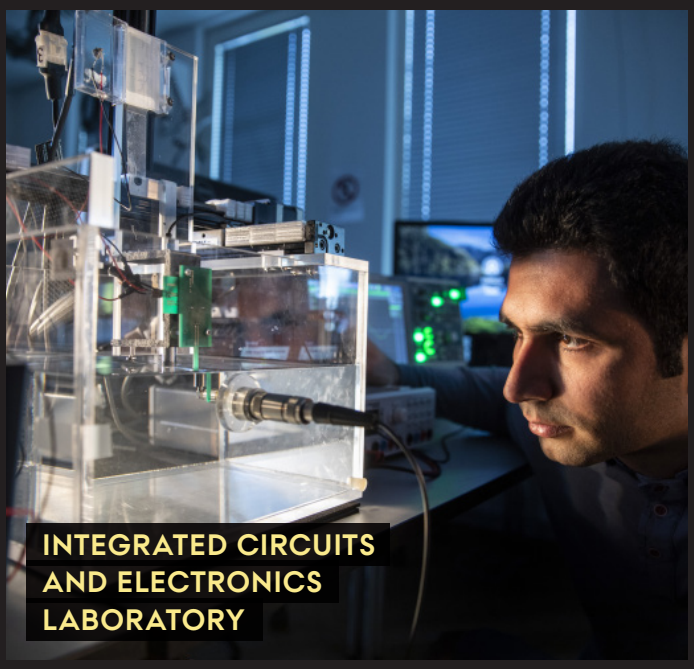
“But reality is beginning to raise its head. I feel that more and more companies are realising that they have to develop to keep up,” she says and continues:

“We need to do more projects like this and give SMEs a taste of how collaboration with knowledge institutions can pay off.”

Facilities

Aarhus University has multiple state-of-the-art theoretical and experimental facilities for research, development, innovation, entrepreneurship and educational activities within the classical engineering disciplines. A selection is shown here.

The facilities are used by students, lecturers and researchers from Aarhus University, and partners from the business community.

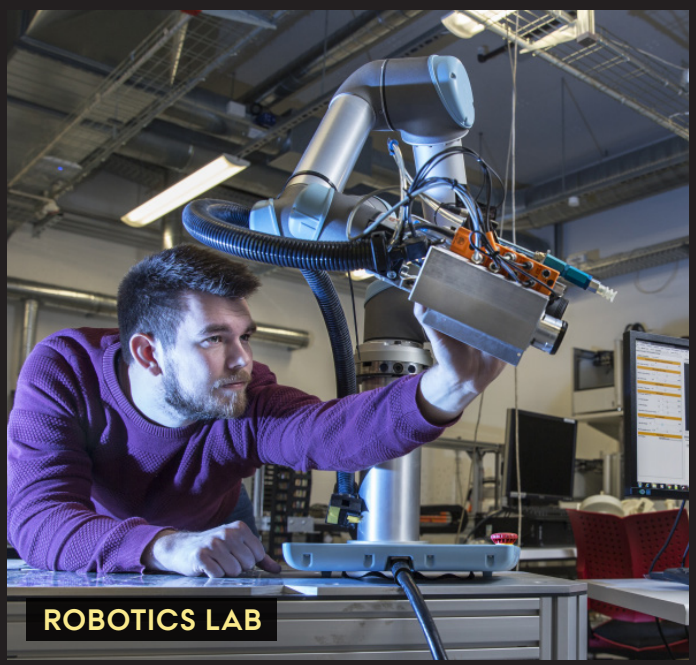


BIOGAS PLANT

CARDIOVASCULAR EXPERIMENTAL LABORATORY

LABORATORY FOR LOAD-BEARING STRUCTURES

NEURO TECHNOLOGY LABORATORY



ROBOTICS LAB

See all facilities online

ECE

DEPARTMENT OF **ELECTRICAL AND COMPUTER ENGINEERING**

ece.au.dk

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.

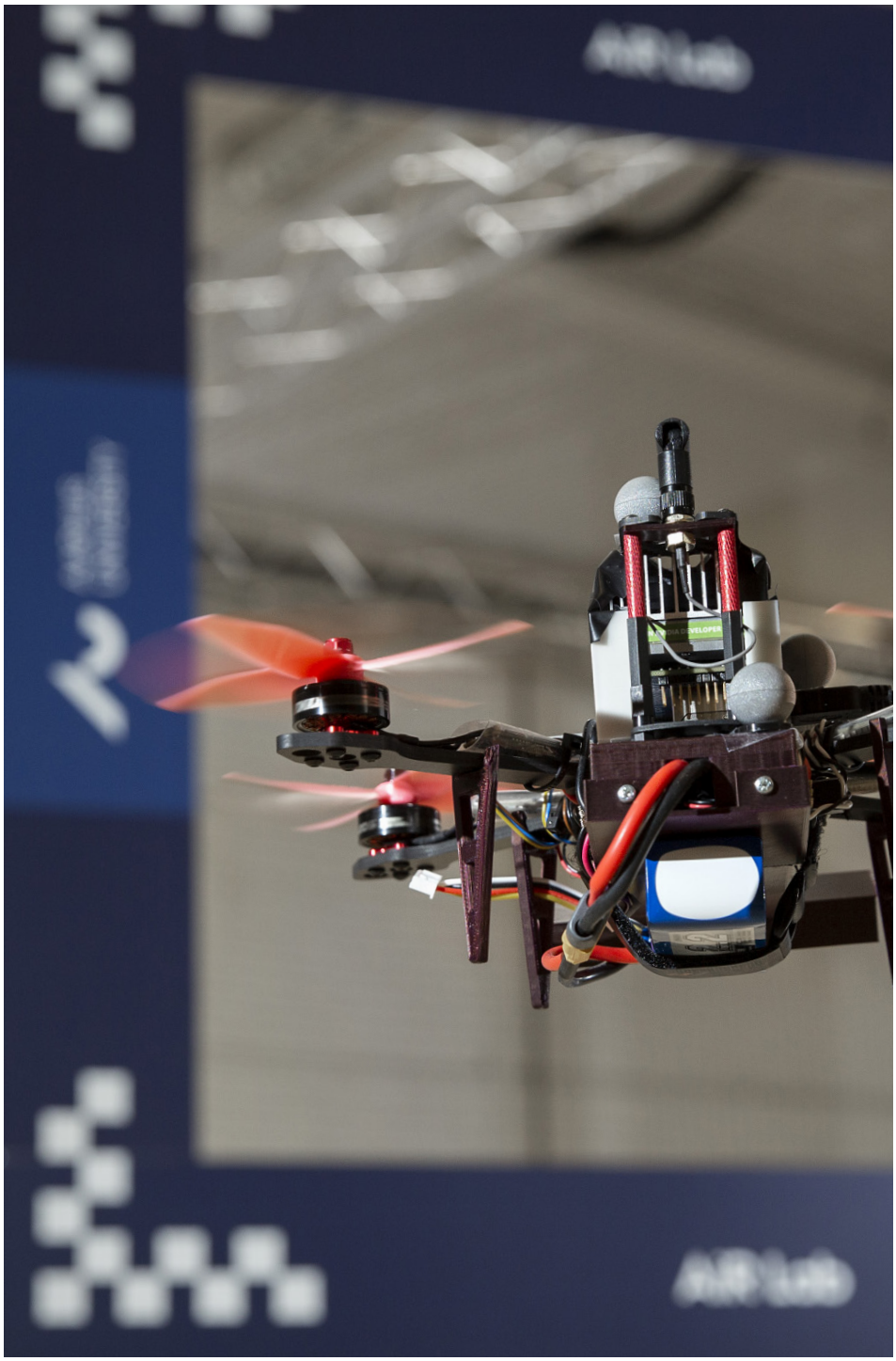


Photo: Lars Kruse, AU Photo

Artificial Intelligence in Robotics Laboratory at the Aarhus University Deep Tech Experimental Hub.

ECE

WHEN THE SPEED OF LIGHT JUST ISN'T FAST ENOUGH

Photo: Lars Kruse, AU Photo

ECE

With a grant from Independent Research Fund Denmark, a team of researchers and experts from industry and Aarhus University will try to solve the fundamental problem that the speed of light simply is not fast enough for the internet of the future.

In the future, human skills will be digitalised and democratised via the Internet of Skills: a future internet that will enable you to use robot technology and haptic feedback to transfer expertise in real time, no matter where you are, and no matter where the problem to be solved is.

For example, imagine a highly specialised surgeon who performs a tele-operation on a patient thousands of kilometres away in which, although a robot is moving the scalpel, the operation feels just as real for the surgeon; as if she were actually moving the scalpel with her own hands.

Physically impossible

This vision however is not possible today. This is because recreating the sense of touch using forces, vibrations or movements on the user, and thus 'fooling' the skin and body into believing that what we are touching in the virtual world is real, requires a network with sub-millisecond delay. Networks with ultra-low latency and ultra-high bandwidth, in which operation command and haptic feedback take place end-to-end with a maximum delay of one thousandth of a second.

Such extremely low latency limits the maximum communication distance to only 150 km, even under ideal conditions. Light cannot travel any further when information has to move backwards and forwards between human operator and remote slave robot within the latency bound.

"Enabling real-time transmission of haptic sensation over the Internet will potentially allow diverse physical operations without humans being physically present. This will pave the way towards the envisioned Internet of Skills which will better disperse and democratise skills and expertise among people, regardless of gender, age, and other diversities. This can reduce the amount of travel and associated CO2 emission. However, the required level of immersion is unattainable over long distances at this stage. Hence, novel solutions are needed to address the challenges," says Associate Professor Qi Zhang from the Department of Electrical and Computer Engineering at Aarhus University.

Digital twin

Qi Zhang is heading a new research and development project called the eTouch, which aims to overcome the physical limitations of today's telecommunications. The aim is to create immediate response, regardless of distance, so that haptic feedback can be perceived by the user without noticeable delay, even though the communication is at a distance of thousands of kilometres.

HAPTIC TECHNOLOGY

Haptic technology aims to create an experience of touch. The technology is also known as kinaesthetic communication or 3D touch, and it works by inflicting forces, vibrations or movements (called haptic feedback) on the user, and in this way letting the user feel something virtually.

Among other things, the technology can be used to create and manage virtual objects and to improve remote control of machines and devices (telerobotics). Haptic devices can use haptic sensors to measure the forces exerted by the user on the interface, thereby creating a genuine sense of being present in the room and actually touching things that in reality are far away.

DIGITAL TWINS

A digital twin is a complete digital model that approximates to a physical system, for example a process or device. 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.

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 by the manufacturing industry for the first time in 2002.

Today, the technology is under intense development. For example, digital twins can provide a completely new layer of technical insight into products and services for manufacturing companies, and there is a big future within robot technology in particular.

The Department of Electrical and Computer Engineering heads Denmark's only centre for digital twins, which is located at Aarhus University.

To solve this problem, the team will leverage Model-Mediated Teleoperation, in which a virtual model (a digit twin) will accurately describe the remote environment, and which locally generates the haptic feedback instantaneously instead of transmitting it over long distances.

However, it is quite challenging to create an accurate model and make effective and reliable model updates in real time with the current data-processing paradigm. Therefore, the team will use Edge Computing paradigm.

Industrial applications

The team will therefore include world-class experts in the fields of edge computing, tele-robot technology and machine learning from the Technical University of Munich (TUM), the Technical University of Dresden (TUD), Aarhus University and industrial stakeholders, including the tech company Rope Robotics.

Nevertheless, the team will not be focusing on tele-surgery, but rather industrial applications with relatively simple operations.

"Realising our vision entails great challenges, so we have to start from the basic operations and take small steps at a time. But if our method works, it could be ground-breaking for the internet of the future and enable the spread of the tactile internet over intercontinental distances and perhaps even in space," says Qi Zhang.

One of the biggest trends of the future

The Danish company, Rope Robotics, is developing robots that can replace the manual labour that is currently required to maintain and repair wind turbine blades.

The goal is a robot system that can crawl around on the wind turbine blades and clean, grind, polish and paint them without human interference.

"It's important for us to have close contact with the leading universities in the world and to be an integral part of the latest research within our field," says Martin Huus Bjerge, CEO of Rope Robotics.

He continues:

"We consider the Internet of Skills as one of the biggest trends of the future, and we're looking forward to working together on this project. It's very exciting, and it may have a major impact on the robot technology we develop."

The eTouch project, which stands for Edge Intelligence for Immersive Telerobotics in Touch-enabled Tactile Internet, is being supported by the Independent Research Fund Denmark with DKK 2.9 million. The project will start in 2022 and run for three years.

Contact:
Qi Zhang
Associate Professor
Department of Electrical
and Computer Engineering
- Communication, Control and Automation

qz@ece.au.dk

ECE

DIGITAL FOCUS

In 2021, Aarhus University inaugurated DTL Ringkøbing-Skjern - the first of several strategically planned laboratories in the Central Denmark Region with a focus on digital transformation. The purpose of the labs is close collaboration between local business communities, local municipalities and the university, linking the entire value chain for new knowledge in Denmark.

dtl.au.dk

Photo: Søren Kjeldgaard

ECE

PHD STUDENT INVENTS A RING FOR LEAKING HEART VALVES

Photo: Anders Trærup

ECE

A small ring around the main artery may cure patients with leaking heart valves. Researchers have documented its effect on animals and they hope they will make it possible to use the technology on humans.

Contact:
Peter Johansen
Associate Professor, Head of Section
Department of Electrical and
Computer Engineering
- Biomedical Engineering

pj@ece.au.dk

A leaking heart valve – or in technical terms, aortic insufficiency – is a condition in which the valve between the left ventricle of the heart and the main artery cannot close completely. The disease can have varying levels of severity and can be caused by congenital malformations or calcification, among other things.

When the aortic valve leaks, some of the blood returns to the heart, which means the heart has to work harder. In the worst cases, this can lead to heart failure, and this is why it's important to treat the condition. Doctors usually treat the condition by repairing the diseased heart valve or replacing it with an artificial valve.

Both involve a risk of complications, and therefore engineers from Aarhus University have been working for several years to develop new surgical technology for heart patients.

"A prosthetic heart valve is an effective form of treatment, but it's also a relatively complicated surgical procedure that brings with it a number of risks and complications in the long term. Now we have found a solution that can make it easier to treat patiens," says Mariam Noor, a PhD student at the Department of Electrical and Computer Engineering at Aarhus University and the Department of Cardiothoracic and Vascular Surgery at Aarhus University Hospital.

Ring prevents blood from returning to the heart

Mariam Noor has spent the last three years designing and developing a ring that can give patients with aortic insufficiency good treatment results, and she has invented something that may have impact on the world of surgery.

"Instead of replacing the defective valve, my treatment concept is to enclose it in the main artery so it prevents blood from returning to the heart. I've developed a new type of ring that tightens around the aortic root to prevent this," she says.

In fact, for several years now, cardiologists have been using a type of ring to stabilise the function of the heart valves, but this has not been without its disadvantages.

The traditional ring is round and relatively rigid, and this limits its operation. Furthermore, placing the ring in the body is a challenge because surgeons have to cut the aorta and remove the coronary arteries.

The new ring developed by Mariam Noor is made of an elastic material that can mould itself to the body's tissue. It also has an opening, which makes it easy to place it correctly.

"The surgical procedure is significantly less invasive, and with the help of diagnostic imaging and 3D printing, we can

adjust the ring's rigidity and strength to the individual patient's anatomy. This gives us some fantastic options, and the technology has been promising during animal trials," says Mariam Noor.

Lots of physics in the main artery
Mariam Noor has especially focused on the material properties and design of the ring in order to better retain the dynamics in the cardiovascular system.

"I look at surgical issues through the lens of an engineer, because there's a lot of physics and mathematics in our cardiovascular system. My approach has been to understand how the aorta works and then transfer this knowledge to design a ring that can recreate normal anatomical conditions in patients," she says.

The ring consists of a silicone core surrounded by suture-like material. In order to document the effect, in collaboration with her colleagues, Mariam Noor has carried out her experiments in a heart simulator, whereby it is possible to control the pump function, temperature and flow.

"We can simulate the action of the heart in a very precise environment that closely resembles the human body. This means we can closely study what happens with the ring in the frequency area of every, single heartbeat. It's been interesting, and we have obtained an incredibly detailed knowledge base to continue working with," she says.

The researchers have subsequently carried out a costly study to see how the ring expands in the body when the heart pumps, and Mariam Noor was positively surprised.

"We looked at the geometric pattern of the main artery in a pig with a ring and in a pig without it, and we could see that we can actually preserve the natural dynamics. These results look really promising," she says.

She emphasises that there are a few years' of clinical approval procedures ahead before the heart ring can benefit patients.

ECE

When clinicians and engineers team up

Engineers will play an even bigger role in the healthcare system over the next years. At Aarhus University we want to develop technology-based solutions that make life better for people, and we want to do this in collaboration with industry, the health sector, academia, and other stakeholders.

New technologies and devices have the potential to change our healthcare sector by improving both diagnostics and treatment of patients in the years to come.

However, this development must be based on strong collaboration between researchers at universities and clinicians at hospitals.

"We have the technological insight and the understanding of health problems from an engineering perspective, while clinicians have the medical and practical expertise in the unique health problems we face. Therefore, strong and close collaboration is an essential part of developing and refining innovative procedures and prosthetic devices," says Associate Professor Peter Johansen from the Department of Electrical and Computer Engineering.

In vitro experimental setups
Peter Johansen is head of the Cardiovascular Instrumentation and Devices research group at Aarhus University. He facilitates various in vitro experimental setups aiming to develop and improve existing clinical treatments and practices.

The focus of his research is on applying engineering principles and skills to understand the functional impact of various diseases, and on testing, evaluating, and developing different cardiovascular prosthetic devices for use in interventional procedures.

"We want to create a direct clinical and industrial edge to scientific discoveries and innovation activities. Our goal is to provide basic knowledge of cardiovascular pathological conditions and various implant characteristics for better and improved patient treatment," says Peter Johansen.

NEW CAMPUS IN FOULUM

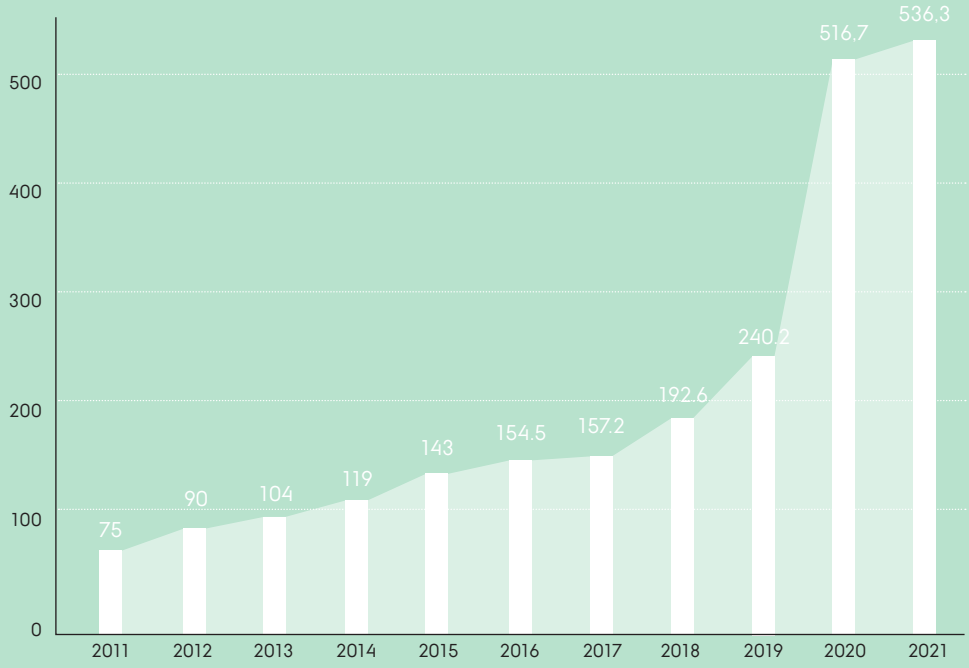
The Faculty of Technical Sciences is establishing a new integrated education and research campus in Foulum near Viborg with up to 800-900 students. This new unified campus, AU Viborg, will serve as a centre for the green transition, veterinary medicine and primary food production in the western part of Denmark.

Go online

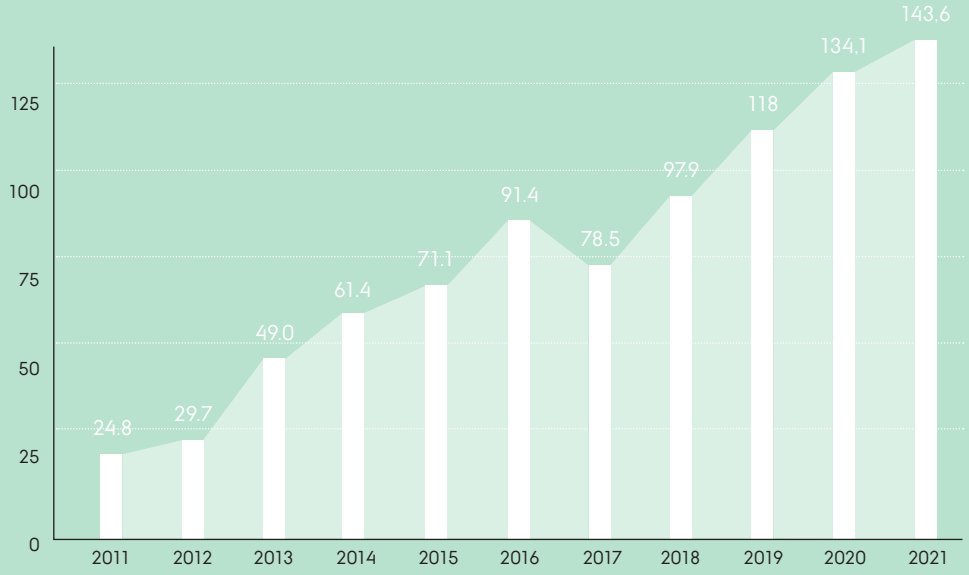
Photo: Anders Trærup

KEY FIGURES
AU ENGINEERING, AARHUS UNIVERSITY

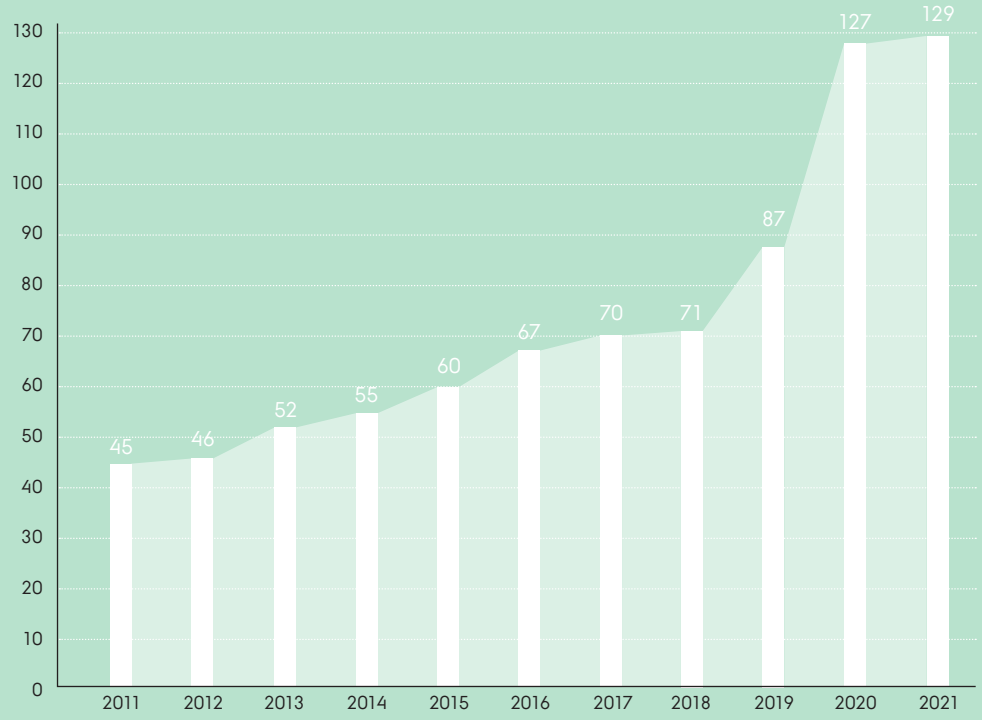
TOTAL ENGINEERING TURNOVER (M DKK)
Based on annual FC3 budget



EXTERNAL FUNDING TOTAL (M DKK)
2021 is based on annual forecast budget

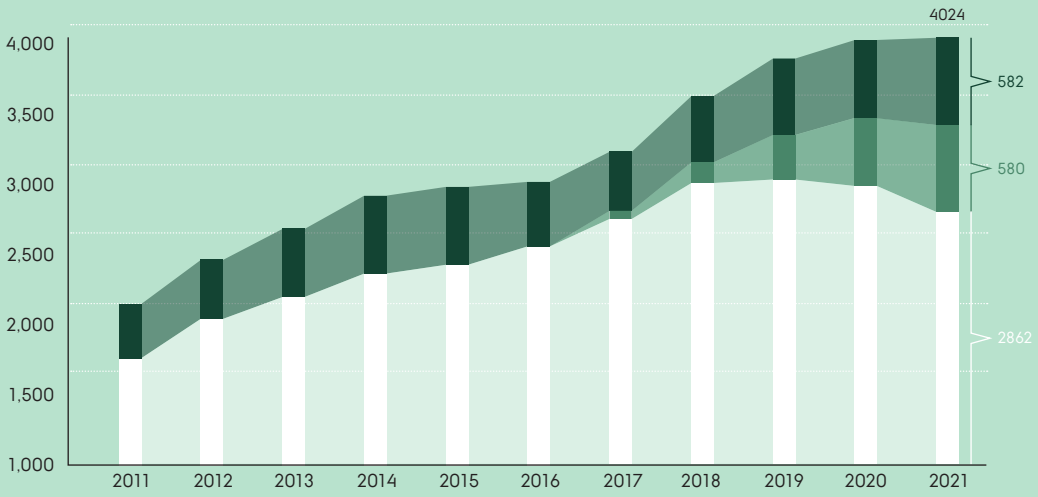


ENGINEERING PHD STUDENTS



ENROLLED ENGINEERING STUDENTS

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



Our demo underground green energy storage facility being built in collaboration with the entrepreneurial company AquaNamic as part of the EUDP funded project Underground Pumped Hydro Storage (UPHS). Other partners include Vestas, SOLMAX, ARKIL, AquaEnergy, European Energy, PlanEnergi and Energicluster Denmark.

Photo: Rene Larsen

AU ENGINEERING, PROFILE 2022

Produced by:
AU Engineering, March 2022

Editors:
Kim Harel and Jesper Bruun

Design & layout:
Nikolai Lander, AU Design

Photos:
Rene Larsen, Anders Trærup, Søren Kjeldgaard, Lars Kruse, Jesper Bruun, Claus Melvad, NASA, 3DCP, Thomas Lundgaard, Kasper Hornbæk, Marjun Danielsen, Jørgen Weber, AART Architects, Jesper Rais, Colourbox, iStock

Print:
Vahle+Nikolaisen

Edition:
1.000 psc

ISBN: 978-87-92829-89-4
ISSN: 2596-8505

engineering.au.dk/profile

Profile 2022 AU Engineering was printed with vegetable-based inks on Munken Polar paper at a press certified by the Nordic Ecolabel. The paper is made of wood from FSC®-certified forestry and other certified sources.

Worn-out industrial milling tools and damaged materials cost the manufacturing industry billions. The need for the next generation of tools is urgent if we are to maintain momentum for Danish competitiveness.

"It's important that we work together across universities and industry to generate new knowledge and to make sure it's implemented in real life."

Read inside, p. 52

CONTACT
AU Engineering
Faculty of Technical Sciences
Aarhus University
Ny Munkegade 118
DK-8000 Aarhus C
Denmark

engineering.au.dk/profile