PROFILE 2017
DEPARTMENT OF ENGINEERING

RESEARCH
TECHNOLOGY
IMPACT

AARHUS
UNIVERSITY

SOLIDUM PETIT IN PROFUNDIS · UNIVERSITAS ARHUSIENSIS ·

DAILY MANAGEMENT AND ADMINISTRATION 2017

Thomas Skjødeberg Toftegaard, Head of Department
Morten Dam Rasmussen, Deputy Head of Department
Jens Kargaard Madsen, Head of Electrical and Computer Engineering
Henrik Myhre Jensen, Head of Mechanical Engineering
Søren Wandahl, Head of Civil and Architectural Engineering
Lars D. M. Ottosen, Head of Biological and Chemical Engineering
Lilian van der Bijl, Head of Secretariat

Contact: eng@au.dk

Department of Engineering
Science and Technology
Aarhus University
Inge Lehmanns Gade 10
DK-8000 Aarhus C
Denmark

eng.au.dk

MACHINE INTELLIGENCE
Magnetic memory in electronics of the future 12
Gearing up wireless technology 14
Robotic productivity to be boosted by dynamic modelling 16
A look through the keyhole of the brain 18
Drop the silo mentality and get smart 20

ADVANCED MATERIALS
The most advanced biorefinery in the world 24
New knowledge about the powerful forces of the sea 26
Danish researchers unleash Darwin to change plastic forever 28
Nano-adhesive to create near-unbreakable metal and rubber bonding 30

ENERGY
Green power for Apple's new data centre 34
Danes use less energy on heating 36
Overloaded: How to save the green energy network of tomorrow 38
Developing the bio-boilers of the future 40
How do you distinguish renewable energy? 42
Smart transition will ensure green energy by 2050 44

HEALTH
Mathematical models behind new cancer images 50
Design provides better patient care 52
There is much more to lighting than flicking a switch 54

PRECISION AGRICULTURE
New technology for reduction of air pollution from farms 58
How deep learning can help farmers get rid of weeds 60
Huge project to demonstrate how the Internet wil fundamentally change farming 62

Publications 2016 66
Patents 2016 92
Key Figures 94

Photo: Melissa Bach Yilderim

AU Engineering, Campus Navitas, Aarhus

Engineering Deep Tech Innovations

As engineers, we strive to build problem-solving technology that benefits not only individuals and businesses, but also society in general. And just like last year, deep tech innovations continue to be of very high priority for us. It is almost as highly prioritised as the two core pillars of any elite university – education and research.

During the short history of engineering at Aarhus University, we have aspired to a standard of excellence that has required a strong innovation culture. This has been essential to the development of research activities within technological fields that address some of the global grand challenges the world is facing today. Our early multidisciplinary focus, anchored in deep engineering disciplines, has enabled us to continue the rapidly increasing number of new research and innovation activities at both national and European levels.

In the past year, we have involved ourselves in a record-breaking 11 new EU-funded projects and 11 new national Innovation Fund Denmark projects. And we have produced 349 peer-reviewed publications.

In 2017, we will keep increasing our effort to get to the next level. We are continuously starting up new activities e.g. within the strategic growth technology domains currently frequently referred to as the fourth industrial revolution or Industry 4.0: machine intelligence and Big Data analytics, hyper-connectivity and Internet of Things, cyber-physical systems, cloud computing, next-generation computing hardware, robotics and nanomaterials, building smart products and even facilitating smart industries. We anticipate that these technologies will keep growing and radically impact business sectors like manufacturing, energy, healthcare and agriculture, including food and water.

Such disruptive changes pose challenges for engineering universities too and, in our attempt to break new ground, we are working hard to solve these challenges. We are investing quite aggressively in new research staff, new facilities and new engineering educational programmes. We continue to strive for increased commercial impact of our research and for general economically viable knowledge transfer to industry.

Above all, however, we continue the dream of actively driving the foundation for a better world where technology equals positive impact.

I am proud to highlight some of our latest engineering projects. They are all examples of innovation at the heart of the global megatrends that drive the transformation of society.

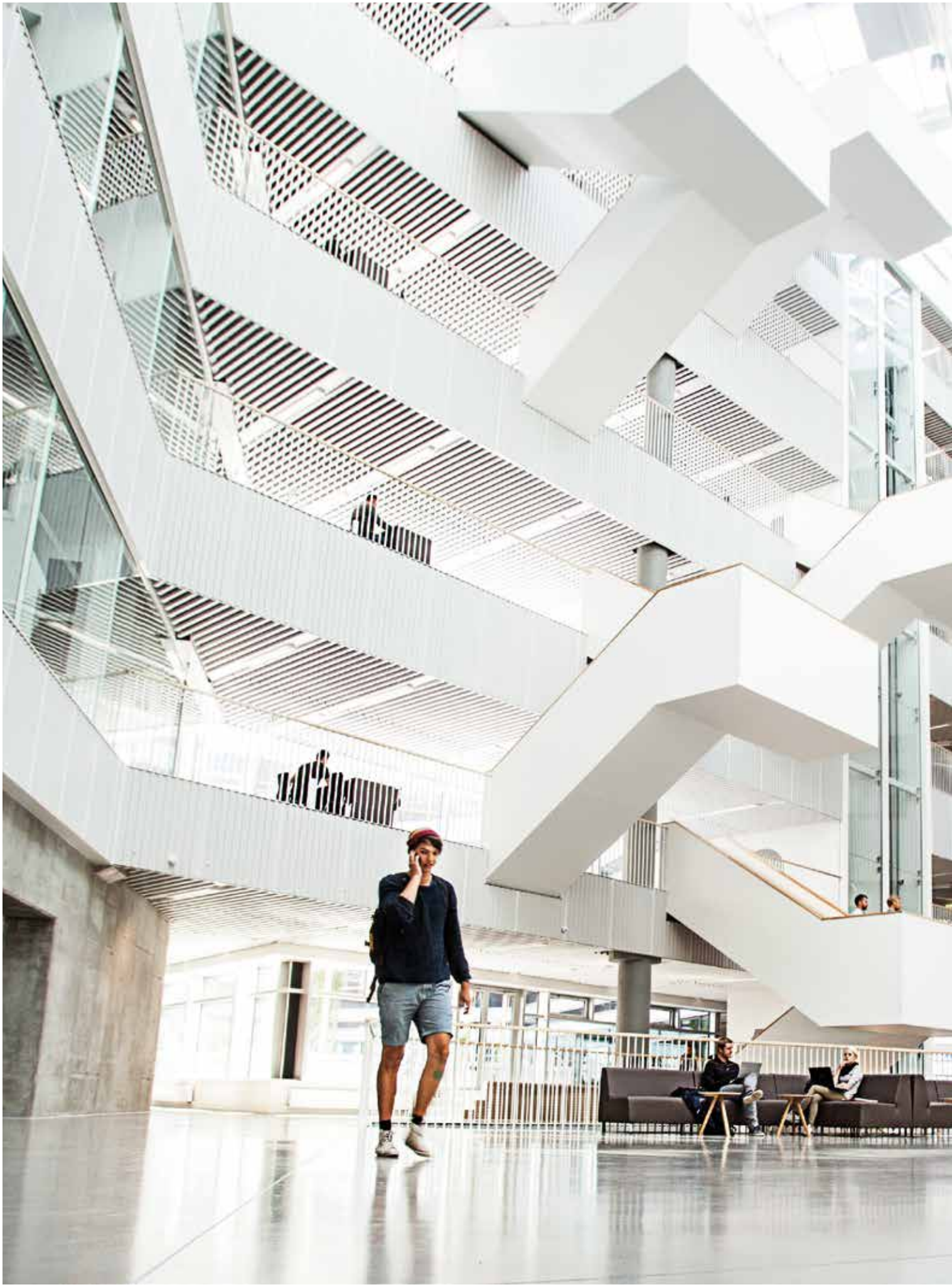
Thomas S. Toftegaard,
Head of Department of Engineering
Aarhus University

”The Department of Engineering at Aarhus University creates innovative and sustainable solutions to some of the major problems facing humanity. We keep a strong focus on technology’s impact throughout all our engineering activities – in deep research, applied and strategic research, partnerships with industry, education, development of PhD programmes, and in our public sector consultancy services.”

Thomas S. Toftegaard,
Head of Department of Engineering

ENGINEERING DISCIPLINES

- **Biological** Engineering
- **Chemical** Engineering
- **Civil** Engineering
- **Architectural** Engineering
- **Electrical** Engineering
- **Computer** Engineering
- **Mechanical** Engineering



AU Engineering, Campus Navitas, Aarhus

Photo: Lars Kruse

MACHINE INTELLIGENCE

We meet intelligent systems each and every day. Digitalisation has made a radical impact on the lives of individuals and competitive conditions for companies. Researchers play a key role in the work involved in utilising technological opportunities in a good, safe and responsible way in fields such as Artificial Intelligence, Internet of Things and Big Data.

project facts

TITLE
Spintronic-Photonic Integrated Circuit Platform for Novel Electronics

SCHEDULE
2016–2019

PARTNERS
Radboud University
SpinTEC
imec
QuantumWise

FINANCIAL FRAMEWORK
DKK 25 million
Horizon 2020, FET OPEN

CONTACT
Associate Professor Martijn Heck
mheck@eng.au.dk

Magnetic memory in electronics of the future

Aarhus University researchers are starting a major European research project. The aim is to develop new technology for the electronics of the future.

With a European Union (EU) grant of more than DKK 25 million, researchers will develop a completely new technology for the computer chips of the future.

The technology is expected to lead to radical new opportunities for storing data and thereby designing computers with very efficient and fast memories in magnetic layers.

"Today, we already have magnetic memory on a chip. This is very promising for energy efficient computing, as no power is required to retain the data. However, writing the data electronically still requires a high energy. Recent research shows that short laser pulses can be used to write data in magnetic layers at much lower energy and much higher speed. Our aim is to use this idea to create a novel optically switched magnetic memory on chip," says Associate Professor Martijn Heck.

Pioneer research in computer technology

The grant is the prestigious Future and Emerging Technologies (FET) actions under Horizon 2020 – the EU Framework Programme for Research and Innovation. FET actions only support pioneer research in ground-breaking new lines of technology that can boost Europe's global competitive advantage.

"The grant helps to put the seal of approval on Aarhus University as an important player in the elite engineering universities. We hope to create new knowledge that can benefit the technological advancement in Europe," says Martijn Heck.

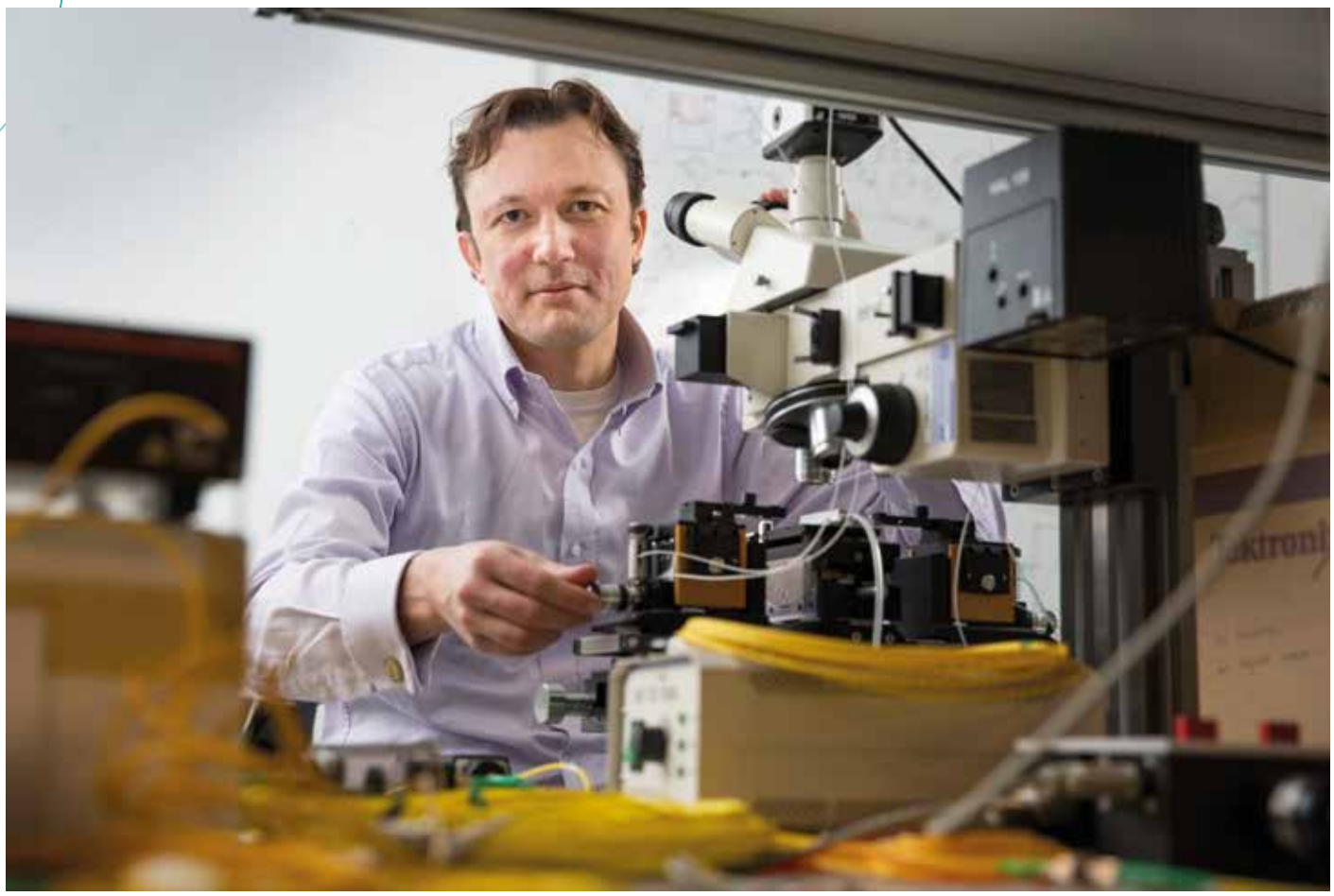


Photo: Lars Kruse

In the coming years, researchers will develop new technology that can accommodate the world's growing need for computers that are even smaller, faster and more energy-efficient. With a prestigious research grant, they will establish a completely new technological foundation for the electronics of the future. Photo: Associate Professor Martijn Heck

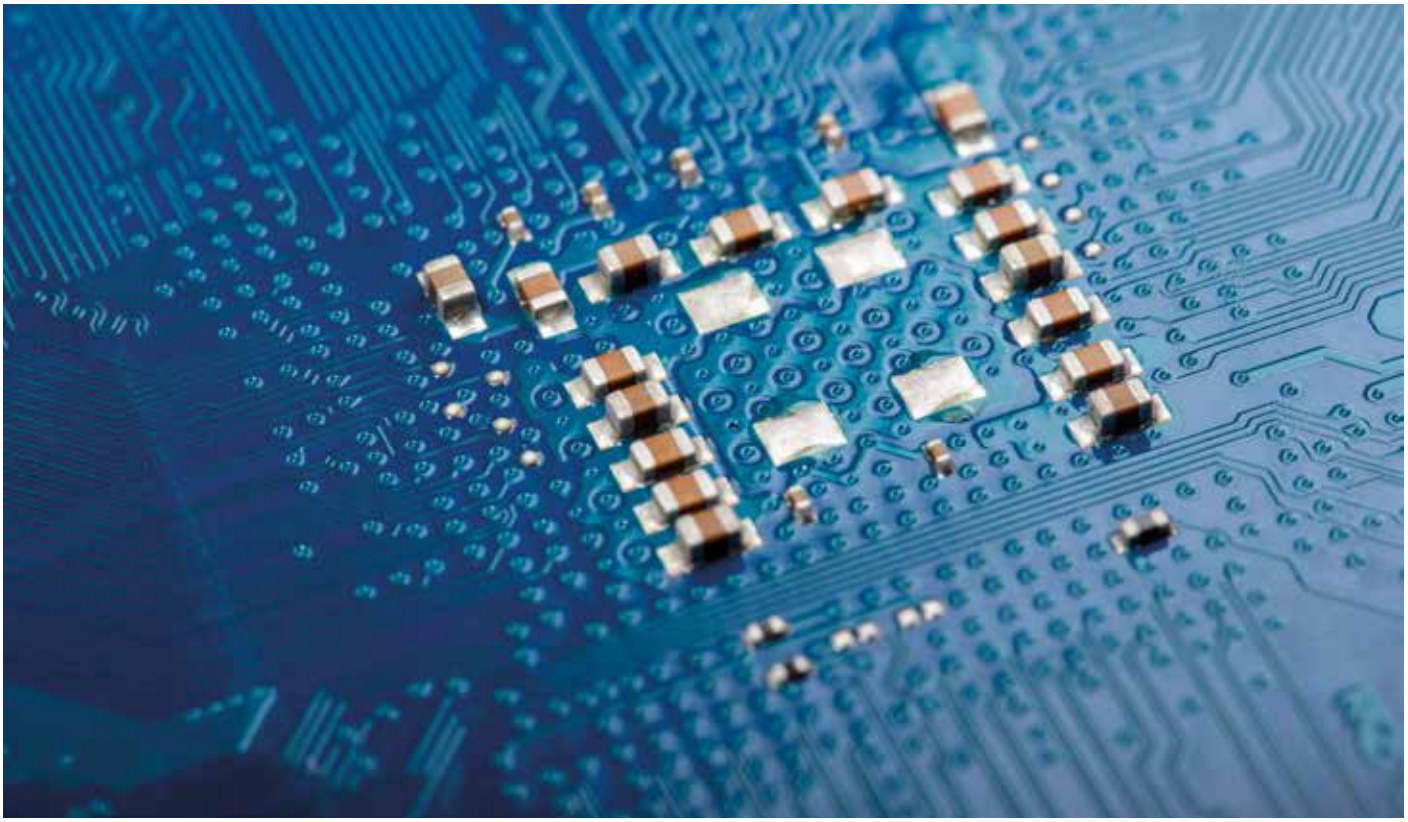


Photo: Colourbox

Gearing up wireless technology

With a new university laboratory, researchers can boost their experimental work with wireless technologies for future networks that effectively and rapidly communicate large amounts of data.

project facts

TITLE
Wireless Transceivers Lab

SCHEDULE
2016–2018

FINANCIAL FRAMEWORK
DKK 2.5 million
Grundfos support grant

CONTACT
Professor Domenico Zito
domenico.zito@eng.au.dk

Aarhus University has established one of the world's most advanced wireless transceiver laboratories, which will help researchers to create new knowledge about future wireless technologies operating at extremely high frequencies in both microwave and millimeter-wave spectra.

One of their most notable research objectives is to develop new radio technologies and thereby devices and methods to transfer large amounts of mobile data at significantly higher speeds than is possible today.

The laboratory is equipped with state-of-the-art technology that includes vector network analysers, signal spectrum analysers, micro-probing stations, noise figure meters, and a noise signal source – all of which can help investigating and solving major scientific challenges regarding future wireless connectivity and contactless sensing applications.

"Working with high frequencies requires specialised and expensive equipment, and it is absolutely crucial for being at the forefront of developing the technologies that can unfold the full potential of the Internet of Things in the time ahead. Our greatest innovation challenge is to create high-capacity, energy-efficient wireless transceivers that can enable data transmissions from several devices at a magnitude we can't do today. We're heading towards a future Internet with high-volume data traffic where machines sense phys-

Photo: Lars Kruse

Professor Domenico Zito will head the research activities of the new Wireless Transceiver Laboratory at Aarhus University. He is an expert in wireless technologies and has international experience both in academic and industrial research and developments. This includes being part of teams behind the first industrial developments of modern short-range wireless systems.

ical parameters of the surrounding environment, communicate with each other and exchange data, thereby making an unprecedented amount of distributed intelligence and automation possible," says Professor Domenico Zito.

Playground for the IT talent of the future

Professor Zito is in charge of the laboratory which came about as a result of financial support from Grundfos Holding and the American multinational company Keysight Technologies. Both of these are important industrial partners, and they share the university's interest in supporting talented researchers and innovators to create a leading international knowledge environment in wireless technology and its applications to address real-world problems and emerging industrial needs.

"We have received an outstanding support from our industrial partners. It is absolutely crucial for our future research that we have access to the most advanced experimental facilities. This is also very important for our ability to educate next-generation engineers in this strategic area for society and economy," says Professor Zito.

The new laboratory will ensure that the engineering graduates of the future have experience with radio technology development for emerging wireless networks and communications.

NEW AU WIRELESS TRANSCEIVER LABORATORY

Wireless technology makes it possible to connect people and machines with each other so that they can exchange data, act and make decisions with a degree of intelligence that would have been unimaginable a few years ago.

In the coming years, researchers at Aarhus University will create new knowledge about radio frequency (RF) transceiver technology and connectivity for emerging wireless communications.

The researchers are among the best in the world at building wireless transceivers into a single silicon chip. This is a key step toward future smart consumer products with unpreceded performance for a considerable number of purposes, and thereby a key element in the digitisation agenda of modern society.

In the coming years, the researchers will use the experimental laboratory facilities to create new knowledge about wireless transceivers for data communication, networking, contactless sensing and imaging in multi-disciplinary fields such as Information and Communication Technology (ICT), Health, Security, Transport, Environment and Space.

Wireless technology monitors babies' breathing

One of the wireless transceiver technology's many application areas is contactless sensing, and the Aarhus University researchers already have a number of interesting projects behind them.

These include the development of a contactless sensor that can detect and monitor people's breathing rhythms. With a prototype size corresponding to a grain of sand, it is now ready for commercialisation.

The researchers developed the sensor within the European research project ProeTEX, and it is based on a pulse radar built on a single silicon chip. The sensor is capable of detecting tiny movements with a high degree of accuracy, making the physiological data available remotely via a wireless connection with very low energy consumption.

"The sensor detects respiration rate by tracking the chest movements while the person is breathing. We've carried out both in vitro and in vivo tests on children and adults, and we have got the proof of concept that we can manufacture efficient sensors for contactless body monitoring," says Professor Domenico Zito.

The sensor can be used for many purposes such as monitoring the breathing patterns of premature babies in hospitals, classifying the level of consciousness of car drivers in order to prevent sudden falling asleep, but to mention a few.

Within the same European project, the researchers have developed radiometric sensor technology for contactless temperature detection, which was recently expanded for spaceborne detection of solar flares above the terrestrial atmosphere in another European project.

The research and development of contactless sensors such as system-on-a-chip pulse radar and radiometer was acknowledged by the European Commission as the successful research project model in ICT for Health across the entire previous European Framework Programme.

Robotic productivity to be boosted by dynamic modelling

The world's leading manufacturer of collaborative robot arms has joined forces with Aarhus University to dampen the vibrations that occur when the robot arms move.

Imagine a row of robot arms that carry out pre-programmed work with superhuman speed and precision – assemble a car, take laboratory samples, or something else completely. Industry has made significant progress since the time when everything was assembled by hand, and it can be hard to imagine that the robots do not accomplish the job as quickly as possible.

But they actually do not. This is because the robot arms generate energy when they move from A to B, and when the arms stop, the energy triggers mechanical vibrations. In other words, if the work requires a high level of precision, the robot has to stop vibrating before it can do what it is meant to.

This can mean delays of a few seconds for each operation, which ultimately makes production more expensive.

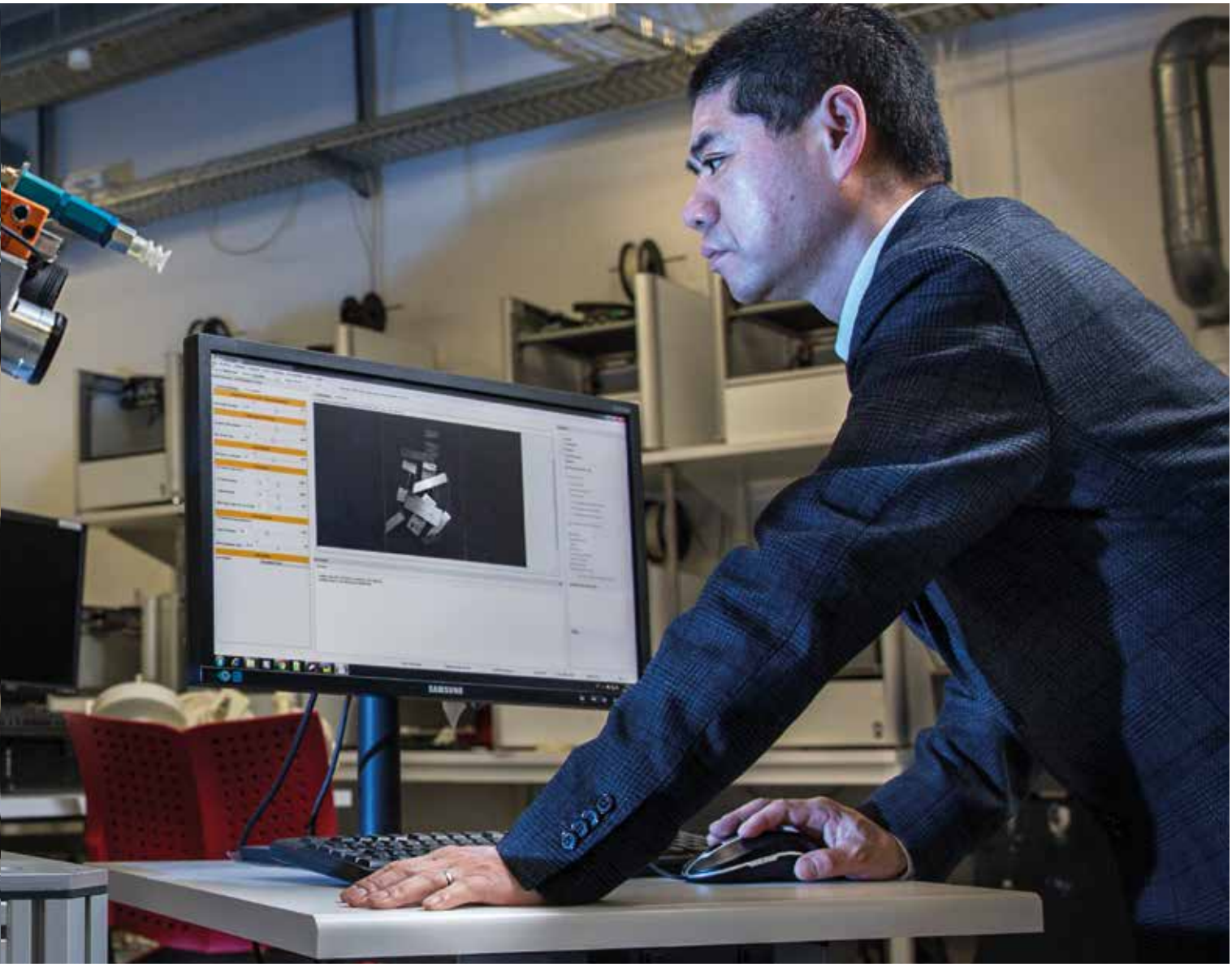


Photo: Lars Kruse

Associate Professor Xuping Zhang (right) and PhD student Dan Kielsholm Thomsen (left) are working on reducing vibrations in a collaborative robot arm from Universal Robots.

Universal Robots in Odense is the world's leading manufacturer of collaborative robot arms – robot arms that do not require shielding, but which can work closely alongside humans.

The company has now teamed up with AU Engineering, Aarhus University, to reduce the amount of vibration during movement. This will mean robots with increased productivity, precision and versatility.

Extremely small margin of error

Precise dynamic modelling will be used to optimise the robots.

"Based on the robot's dynamic properties, we can determine the best way possible to move from A to B, so we avoid introducing vibrations in the system," says PhD student Dan Kielsholm Thomsen, who is researching the problem.

Robot arms that mount elements on a circuit board, for example, have an extremely small margin of error. Here it is no good having a robot arm that vibrates, even though the amplitude of the movement is less than one millimetre.

Using active vibration suppression, Dan Kielsholm Thomsen hopes to reduce the vibrations to a tenth. This can significantly speed up production at the same time as increasing the service life of the arm as the vibrations can be hard on gears and joints in the long run.

"If there are endless ways of moving from A to B, which movement is the best? We need to be able to determine this in a fraction of a second, so calculations are necessary," says Dan Kielsholm Thomsen.

project facts

TITLE
Vibration analysis and control of UR robot manipulators with the consideration of link and joint flexibility

SCHEDULE
2016-2019

PROJECT PARTNERS
Universal Robots

CONTACT
Associate Professor Xuping Zhang
xuzh@ase.au.dk
PhD student Dan Kielsholm Thomsen
dkt@eng.au.dk

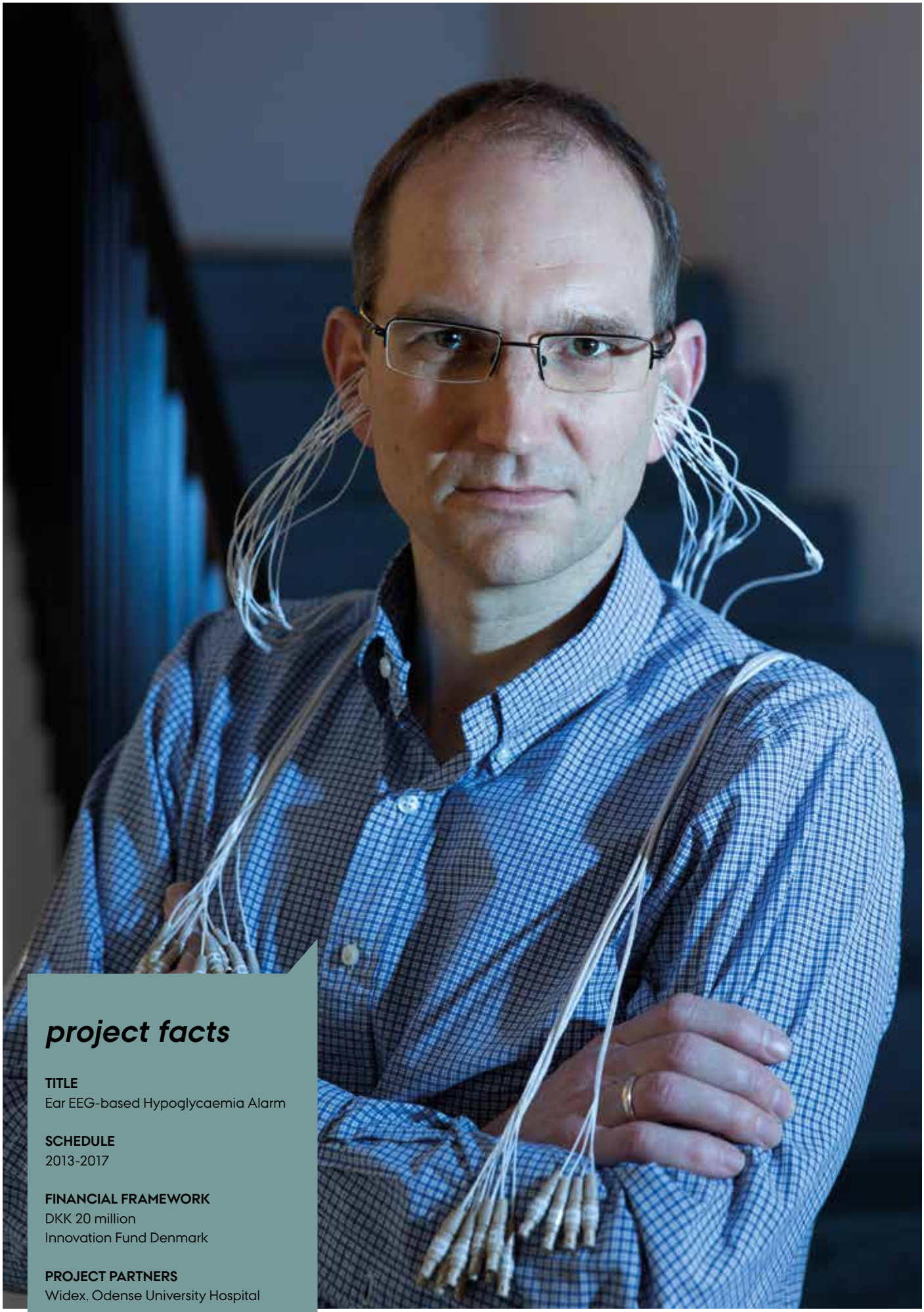


Photo: Lars Kruse

Professor (Docent) Preben Kidmose believes that in-the-ear EEG measurements have great prospects for passive monitoring of factors such as the brain's cognitive state.

project facts

TITLE
Ear EEG-based Hypoglycaemia Alarm

SCHEDULE
2013-2017

FINANCIAL FRAMEWORK
DKK 20 million
Innovation Fund Denmark

PROJECT PARTNERS
Widex, Odense University Hospital

CONTACT
Professor (Docent) Preben Kidmose
pki@eng.au.dk

A look through the keyhole of the brain

How do you get information out of the brain? Researchers at Aarhus University are carrying out research into taking passive measurements of the brain's electrical signals and piecing them together into a larger image of the brain's cognitive state.

Ever since the German psychiatrist Hans Berger first measured the electrical activity of the brain on a human in 1924, electroencephalography or EEG has been widely used as a non-invasive diagnostic tool for different brain conditions such as epilepsy and sleep disturbances.

The method involves placing electrodes on the patient's head, and has been hailed as one of the most surprising, remarkable and significant developments in clinical neurology. The electrodes measure electrical signals related to brain activity.

However, electroencephalography can be used for much more than diagnosing. Coupling it with computer technology and Big Data, researchers have now developed an opportunity for a simple form of mind control and mind reading, and it does not require much imagination to picture the endless opportunities that are thereby opened up.

A narrow bandwidth

Researchers at Aarhus University have developed what they call an Ear-EEG – a small appliance that can be placed in the ear to perform a simple type of EEG. This means that the researchers can collect data over longer periods because patients do not need to go around with several hundred electrodes on their heads.

Such passive measurements of brain activity are interesting in relation to activities such as monitoring circadian rhythms and cognitive states, particularly regarding psychiatric disorders – a world that is crying out for objective information about patient conditions, according to Professor (Docent) Preben Kidmose who is one of the world's leading experts in taking in-the-ear EEG measurements.

However, there are far greater prospects ahead.

"How do you get information out of the brain? Normally, the only way we can do it is by moving – i.e. talking, gesticulating, etc. But, in principle, this is a very slow form of communication. The bandwidth, if you can call it that, is very narrow. Just think how many thoughts you can generate in your head in the same time it takes to utter just ten words. It would be very interesting if you could open the floodgates. That's what's interesting – how to get bits and information out of the brain," he says.

This is not just something you do. Particularly if the technology has to be non-invasive.

We can only see the massive torrents

There are approximately 80 billion neurons in the human brain – special types of cells that can emit electrical signals, and which combined form the key elements in the brain and central nervous system. Each individual neuron is a small calculator that can join up with other neurons and form neural networks running through the brain.

If you really want to open the floodgates, you should therefore be able to draw out information from each individual neuron, but this is impossible. You can only see the entirety, according to Professor (Docent) Kidmose.

"Imagine it's raining in a huge mountain landscape. The raindrops that fall on each individual stone and mountain peak slowly run together in small streams that, in turn, merge with others and eventually form large rivers and torrents in the valleys. With the technology we've got today, with electrodes placed on the head, it's these huge torrents we can see. Nothing else," he explains.

Previous knowledge can open the door

This is why the 'bandwidth' in thought-controlled technology today is even slower than normally operated technology. For example, it is possible to use electroencephalography to write words by thinking of the letters you use.

"But doing so occupies your entire cognitive capacity. You have to focus very hard on one single letter at a time to be able to read it on the brainwaves using external electrodes on the head. You can steer a wheelchair the same way, but it's easier to do so with your tongue because the technology requires you to focus so much on the one action you want," says Professor (Docent) Kidmose.

"As long as we have to measure outside the brain, the bandwidth is low," he continues.

However, there is a great potential for in-the-ear EEG measurements. After all, it is the turbulent rivers that cut through the rocks and form the landscape. And in the same way, it is possible that familiarity with the overall electrical thought flow can work out what is going on in detail.

"If 200 electrodes on the head are an open door, then Ear-EEG is a look through the keyhole. But if you have previous knowledge of what's going on in the room, it could be that you can form an impression of what's happening in the entire room simply by taking a look through the keyhole," he says.

Drop the silo mentality and get smart

The Internet of Things, Big Data and Artificial Intelligence are paving the way for completely new opportunities and business models for companies. However, they need to create smart products and do away with conventional thinking.

The world is changing.

A telephone is no longer simply a piece of equipment used to make a call, and a car is no longer just something used to transport oneself from A to B.

In a world in which computer technology is constantly making new breakthroughs, where hardware is constantly becoming faster and smaller, and where computer chips are no longer just something soldered to a motherboard, it is no longer sufficient to be good at things one has always done.

Technology changes the products that have always been taken for granted, and the glorious production companies of the past now see themselves in competition with companies they could never in their wildest dreams have imagined just a decade ago. Intelligent thermostats from Nest, for example, use Google algorithms to teach themselves how they should be adjusted, making them a serious competitor to Danfoss today.

To survive in the current and future global market, it can therefore be necessary for production companies to completely rethink their business model. If not, it could mean that they become swallowed up by development. This happened to Nokia, for example, the Finnish telecommunications giant that completely lost its leading global position when Apple introduced the iPhone.

Climbing the ladder

A considerable number of production companies have therefore joined forces with institutions including Aarhus University, which will help the companies to make their products smart in collaboration with a number of partners. The project is called MADE Digital, and it is funded by Innovation Fund Denmark. The project contains nine work packages and the one that addresses smart industrial products is called WP1. Professor Peter Gorm Larsen heads the work in this work package.

"To be smart, companies and their products need to climb a ladder. In addition to the basic product, there are four steps on the ladder leading to a completely autonomic solution – in cases where this is desirable. What's essential for the companies is to determine where they want to end up on the ladder," he says.

The first step is concerned with monitoring. This typically involves building a sensor into a product to monitor whether the product requires service, for example. Here the Internet of Things (IoT) is one of the technologies that makes it possible to communicate data out. The next step is to be capable of checking the product with integrated software that can take action based on sensor data. A cyber-physical system (CPS) is the name of the technology that is necessary when there is a close correlation between the physical part of the product and the software used to control it.

The third step is about automatic product optimisation – how to do things better by using technologies such as Big Data analysis or machine learning to break down large amounts of information about the product's behaviour. The last step on the ladder is full autonomy, where the computer is in complete control of the product with no human interaction so that it makes its own diagnosis and takes possible errors into consideration, and can even optimise and coordinate with other products and systems.

Enable dialogue between professions

Disregarding the last step, which according to Professor Larsen is clearly the most exciting from a technological point of

project facts

TITLE
MADE Digital Smart industrial products

SCHEDULE
2017-2019

FINANCIAL FRAMEWORK
DKK 196 million.
Innovation Fund Denmark

PROJECT PARTNERS
There are 59 partners in MADE Digital.

CONTACT
Professor Peter Gorm Larsen
pgl@eng.au.dk

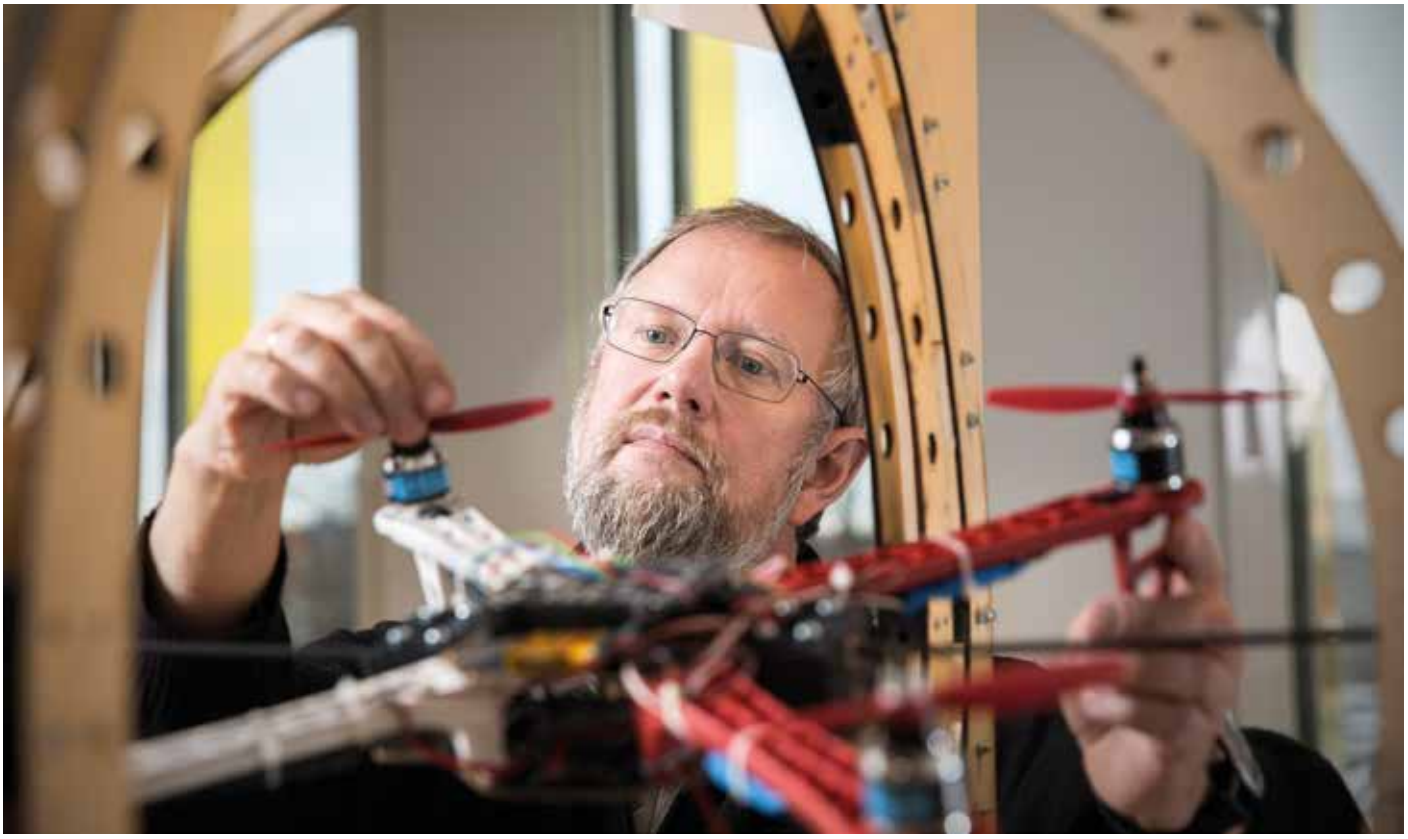


Photo: Lars Kruse

The Internet of Things and Big Data are changing the world and turning the retail industry upside down. Who could have expected that an online bookstore such as Amazon – which is currently in full swing implementing automatic drone delivery – could become a serious competitor to everything from supermarkets to electronics dealers?

view but also the most difficult and challenging, it could be tempting to think that the engineering challenges are right up our street. However, the real problem with making products smart is, in fact, not exclusively optimising the physical product, according to Professor Larsen.

"The major challenge for companies is typically to do away with silo mentality. To break down barriers internally. To do things smarter requires a multidisciplinary understanding of the disciplines that must be used to achieve the physical transformation of the product. It's not enough to have a mechanics department, a software department, and an electronics department, where each one only focuses on its own field. We need instead to do something that makes close dialogue possible between the professions so they can understand each other and not delay the development of a new product. In my opinion, this is a problem that goes right back to our education system, and it's really something we need to work on," he says.

It is thus the internal processes in development and production that must be reconsidered. When developing something in the old days that had a mechanical part controlled by software, the mechanical part was built first. When that was finished, a start could be made on developing the software.

"But this is much too slow in relation to the world today. Sharply dividing the stages into development and production doesn't work," says Professor Larsen.

"Today you simulate the products before you build them. Before you have the finished mechanics, you've made a model of it, used differential equations to model how it will behave physically, made the control part as a model based on discrete mathematics, and run the whole thing through. By simulating the thing first, you can very easily find out what's right and what's wrong to do before you build it," he continues.

Helping the industry

This is where Aarhus University can help the production companies. The university's researchers have developed software that can help companies simulate a smart upgrading of their product. This makes them a good sounding board for industry in Denmark because the software makes it possible to help companies clarify the best way to turn when there are many options. The university also helps companies to find the most sensible technologies to use to reach the step they want on the ladder with a view to the future.

Professor Larsen provides the following example. A large Danish company called C.C. Jensen is a market leader in oil filtering systems. To put it plainly, they manufacture oil filters for applications such as marine engines. The company has now produced a sensor that can measure the oil when it runs through the filter, and this is smart because the filter can thereby provide information about the condition of the engine. The next step in the chain is to make use of the data produced by the sensor, but how can information be communicated from an oil filter located in another part of the world? And how much 'power' should the filter have if the sensor's measurements are to be exploited? Should it be able to stop the motor, for example, if it registers a fault? These are some of the issues that the Aarhus University researchers are now helping to solve.

There are many technical challenges involved in making products smarter than they already were. This also means that the upgraded product can end up becoming more expensive than it was initially. However, the extra cost can mean that the customer gets an extra service that makes it worth the price. A new marine engine is expensive, so a smart oil filter that can alert the user before the engine breaks down is no doubt worth the price. In the same way, people all over the world found that the extra services provided by a smartphone were worth the higher price tag.

ADVANCED MATERIALS

New materials with properties that we hardly dare dream of today will see the light of day in the near future. We are on the threshold of yet another industrial revolution where technology will pave the way for completely new inventions and advances in a considerable number of areas. Examples are space, health care and manufacturing through e.g. 3D printing.

The most advanced biorefinery in the world

In the new Centre for Biorefining Technologies at Aarhus University, researchers will create knowledge and technology that can contribute to the exploitation of biomass for high-value products.

The activities at the centre aim to create the knowledge required to strengthen the preconditions for producing a range of new green products that are currently either imported or extracted from fossil fuels.

These products include new sources of protein for animal feed and raw materials for many different industrial purposes – all produced in a refining process based on biomass extracted from crop residue, straw, grasses and other plant matters that do not compete with food production.

"We're working on creating a highly efficient biorefinery and providing leading examples of how to kick-start a bio-based economy with sustainable high-value products such as proteins, polymers, and new chemical or biological components for industry," says Associate Professor Ib Johannsen.

He is responsible for the centre's engineering research and development activities regarding production systems and technologies for refining green biomass.

Photo: Anders Trærup

Non-food plants and residue can be used for fuel, high-value chemicals, and animal feed. But how do you cultivate new, optimised types of green biomass? How are they harvested? And how do you make the most efficient use of them for new products? Associate Professor Ib Jonansen (left) is spearheading a new research centre that will create novel sustainable solutions for biorefining technologies for upgrading plant material into products.

High-protein animal feed from grass

Sustainable feed produced from grass can eventually provide a replacement for the large amounts of imported soya that European pigs consume every day.

project facts

TITLE
BioValue

SCHEDULE
2013–2018

FINANCIAL FRAMEWORK
DKK 160 million
SPIR, Innovation Fund Denmark

PROJECT PARTNERS
Aalborg University
University of Copenhagen
Technical University of Denmark
Arla Foods
Hamlet Protein
KMC
Kongskilde
DELG
Haldor Topsoe
Novozymes
Rockwool
Borregaard
Danish Agriculture & Food Council
Agrotech
Imbiom

CONTACT
Associate Professor Ib Johannsen,
ibj@eng.au.dk

Green juice in a freeze-dried variant. This is what it looks like – the product produced by Aarhus University researchers in some of the most extensive pilot experiments to date in extracting protein from biomass. The juice is a concentrate of selected grass species and contains proteins that can meet the amino acid needs of most large mammals.

With this juice, the researchers have solved one of the major challenges in a refining process that has been under way since the Second World War.

They can now optimise the separation of the biomass into various components and remove those parts of the plants that are indigestible and which inhibit the absorption of protein.

"Our aim has been to design a refining process so that we can convert green biomass to highly absorbable protein concentrate for pigs at the same time as utilising the residual components in feed for ruminants. This will enable us to create a locally produced alternative to soya," says Postdoctoral Fellow Morten Ambye-Jensen.

An attractive alternative to soya
The researchers are now working on more methods to extract protein from different types of crops. They have good experience with both heating and fermenting, and have already completed the first major test production at the university's pilot plant.

Subsequently, they used the resulting green protein in a feed experiment with pigs, aimed at studying amino acid absorbability.

"The major engineering challenge is now to create a production process that is both financially viable and environmentally sustainable, and which provides a product with high protein absorption," says Morten Ambye-Jensen.

Aarhus University has unique facilities for biomass production as well as world-class research in animal nutrition. The researchers expect that the technology for producing green protein will be ready for commercial use in the course of five years.

EU countries currently import more than 45 million tons of soya per year for animal feed with an enormous impact on the climate from both production and transport. The considerable environmental benefit of using grass for feed is that it can be grown locally with low use of pesticides and minimal leaching of fertilisers.

New knowledge about the powerful forces of the sea

Experiments in the open sea create new knowledge about how waves originate, develop and affect the surroundings with their strength. This will make it possible to maintain facilities such as oil platforms in the North Sea for a longer period of time.

Using mathematical and physical theory and advanced computer simulation, researchers all over the world have been working for decades on describing waves and wave loading. They have become adept at analysing how the sea absorbs energy from the wind and converts it to waves that break and interact with each other, ocean currents and the format of the sea bed.

However, there is a certain amount of uncertainty associated with the existing theoretical, numerical and analytical descriptions of wave loading. Reality is often far more stochastic than can be accounted for, even using advanced simulations. Danish wave researchers will therefore now start using full-scale measurements.

"We'll create new knowledge about wave loading with a focus on how it affects offshore structures. It's very difficult to upscale experimental results of the way fluids flow around an object, and we therefore need studies at sea. With new full-scale tests, we can gain more reliable and accurate insight into how waves interact and fatigue our oil platforms in the North Sea," says Professor Christos Thomas Georgakis.

Until recently, he was responsible for the scientific activities regarding wave loading at the Danish Hydrocarbon Research and Technology Centre, the overall aim of which is to identify new technological solutions that boost oil and gas extraction in the Danish sector of the North Sea.

Improved safety on large platforms

One of the main objectives of the wave research at Aarhus University is to reduce the expenses that are currently associated with repair, retrofit and maintenance of the existing oil platforms. It actually requires detailed familiarity with the way ocean movements continuously wear down the constructions through corrosion and fatigue.

"North Sea oil is a valuable energy resource for Denmark, and it will unfortunately not last forever. It's therefore crucial that we get as much as possible out of it – with the least possible resource consumption. The sea causes enormous wear on offshore constructions, and the engineering challenge is to more accurately identify how much they can withstand. Today we have to shut down the oil platforms in some cases because we don't know whether they can withstand the wave loading," says Professor Georgakis.

He expects that more accurate knowledge about the interaction between loading and wave structure will make it possible to take decisions on an informed basis and extend the service life of the platforms in the North Sea until such time as Denmark is ready for a complete green transition.

"We'll develop a reliable method to characterise waves and predict the consequences of their loading. The oil and gas industry needs new knowledge for making decisions about which platforms they should shut down or keep running, and what maintenance and retrofit measures they should invest in," he continues.

Studies in the laboratory and at sea

In order to understand the mechanisms underlying the wear and tear of the waves, the researchers will also start using large areas of the North Sea for near full-scale experiments. Using laser technology, they are studying conditions such as the form and distribution of the waves as well as the undercurrent conditions in natural surroundings.

They are also planning to equip an unmanned oil platform with different sensors and scanners that measure the direct response of the construction to the waves in the form of vibrations.

The researchers are comparing all of this with the results of extensive experiments in one of the world's most advanced wave tanks at Newcastle University which can combine waves, wind and current. In this way, they can systematically identify the computational uncertainties connected with simulating real sea conditions.

"By comparing tests at sea with tank experiments, we hope to create a better load model and thereby more accurate assessments of the impact of wave loading on offshore constructions," says Professor Georgakis. The researchers will eventually use the test results to develop offshore constructions that are capable of reducing the wear and tear of the sea based on the design alone.

Photo: Lars Kruse

project facts

TITLE
Extreme Waves – Direct and Indirect Load Estimation

SCHEDULE
2016-2020

FINANCIAL FRAMEWORK
DKK 8.5 MILLION
Danish Hydrocarbon Research and Technology Centre (DHRTC)

PROJECT PARTNERS
DHRTC
DTU
Maersk Oil & Gas
Newcastle University

CONTACT
Professor Christos T. Georgakis;
cg@eng.au.dk

NEW TECHNOLOGY TO EXTEND THE DANISH OIL JOURNEY

Denmark has produced oil for more than forty years, but now there is an acute need for innovation and new technology insight in order to continue extraction from the underground.

The Danish Underground Consortium (DUC) has initiated the establishment of the Danish Hydrocarbon Research and Technology Centre (DHRTC) in collaboration with Aarhus University, other leading Danish and foreign universities and industry. The centre's efforts are directly aimed at improving oil and gas production from the Danish sector of the North Sea.

Professor Georgakis is a structural dynamicist and expert on fluid-structure interaction. He studies how waves put a strain on offshore structures, and he thereby creates valuable knowledge about how to get as much as possible out of oil and gas resources in the North Sea.

Danish researchers unleash Darwin to change plastic forever

Imagine a future where plastic is sustainable, green, biodegradable and manufactured without chemistry. A team of researchers is hoping to achieve exactly this by means of a 'green soup' of microalgae.

Natural rubber was used for centuries by indigenous populations around the world, but it was not until the industrial revolution in the 19th century that plastic as we know it today was introduced by Alexander Parkes in 1862. Ever since, and particularly after World War II, plastic has spread to engulf every aspect of our lives.

Particularly as of late, this has also spread to our oceans, where heaps of photodegraded plastic form gigantic 'garbage patches' – diffuse soups of floating plastic that is not biodegradable but enters the food chain via ingestion by aquatic organisms.

Ever since concerns about adverse health effects from plastics and plasticisers – the latter of which, since their discovery in the wake of World War II, have been derived from petroleum-based chemicals – scientists have struggled to find a viable bio and ecosustainable substitute that is suitable for industrial use, i.e. cheap to produce in large quantities.

From lipids to bio-polymers

Researchers at Aarhus University, in collaboration with colleagues at the Technical University of Denmark, the University of Cambridge and Kyoto University, have now come up with a possible solution – polymers produced from microalgae.

"Most chemicals today are made from petroleum, but that won't be around forever and it isn't sustainable. We need technology that doesn't harm the environment," says Associate Professor Zheng Guo.

The idea is to extract oil from the algae and subject the fatty acids in the oil to the right enzymes. This way the researchers can transform the lipids into polymers. Polymers that are sustainable, manufactured using green biotechnology, without chemistry, and that are biodegradable and harmless to the environment. Polymers that, in principle, can be used to create any kind of plastic.

"They basically resemble LEGO® blocks that originate from microalgae. The blocks can be assembled to create any design. These are harmless and only contain biological molecules. That's what we hope to develop," says Associate Professor Peter Kristensen.

Improving nature by natural evolution

The process requires protein engineering. To convert the lipids extracted from microalgae into polymers, the lipids need to be chemically modified. This can be done by enzymes, but the enzymes that exist are not optimal for the process. Instead, the researchers engineer the right enzymes for the job via natural mutational evolution. This is where Charles Darwin is unleashed.

"Nature has already created enzymes that can do the job but not very efficiently. We'll improve the enzymes so we can use their green properties in industry," says Associate Professor Zheng Guo, whose colleague Associate Professor Kristensen elaborates:

"We take an existing enzyme and optimise it via mutations. These are random

Photo: Lars Kruse

Plastic surrounds us everywhere and is of fundamental importance for our lives as they are today. However, the non-biodegradability of plastics is harming nature all over the world. Associate Professor Zheng Guo (left) and Associate Professor Peter Kristensen (right) therefore hope to be able to use microalgae to create organic plastic in the future.

processes that constantly occur in biological systems. Most have no beneficial effect and are ignored but, once in a while, a mutation can cause a positive effect. This effect is then implemented in the biological system. Thus the system evolves."

Thanks to Kyoto University, the researchers already know which enzyme to begin with. Here project collaborators have isolated a specific enzyme that can catalyse the first step in producing plastic from microalgae.

This enzyme can change the properties of lipids by attaching a hydroxyl group to the lipid molecular chain at a specific point. However, in order to create the wanted polymers, a second step needs to be taken, converting the hydroxyl group into a carboxylic acid. This second step will also be catalysed by an enzyme, which will be the next step the researchers will address.

Creating a library of enzymes

"Enzymes are proteins in the biological system. Each and every one is created from the information stored in the DNA of the system. You can say that the DNA is the recipe for the enzymes, so we change a bit of text here and there to create an entire library of different enzymes. Then we look at the entire pool of mutated enzymes and choose the best one for the task through selection," says Associate Professor Kristensen.

Nature has evolved this way since the dawn of time. Because of mutations and natural selection, life is able to survive in the most incredible places on earth: at the bottom of the ocean where no light ever reaches, to the highest peak of the Himalayas, and the coldest tip of the Antarctic.

"Nature sometimes goes beyond your imagination. Enzymes can survive at unbelievable places and have the most amazing properties," says Associate Professor Zheng Guo.

project facts

TITLE
Aquaculturing biochemicals for the future: enable production of hydroxyl fatty acids by microbial hydratase

SCHEDULE
2017-2020

FINANCIAL FRAMEWORK
DKK 2.2 million
Novo Nordisk Foundation

PROJECT PARTNERS
Kyoto University
Technical University of Denmark

CONTACT
Associate Professor Zheng Guo,
guo@eng.au.dk
Associate Professor Peter Kristensen,
pk@eng.au.dk

Nano-adhesives to create near-unbreakable metal and rubber bonding

Adhesives are used throughout industry, but many contain toxics and others are not reliable or durable. But what if you could merge two materials together using clean molecular bonding? That is exactly what scientists are working on right now.

Have you ever hassled with tearing off a glass bottle label, getting more and more agitated as the label just shreds when you try to peel it off and its remains seem moulded onto the bottle – impossible to get off?

Adhesives are used for a great many purposes in our world (from an annoying fly sticking to the window to the space industry) and can sometimes lead to frustration when they adhere too well – or not well enough.

But sometimes it is desirable to 'glue' two things together intending the materials to remain linked forever – no matter what conditions the bond is exposed to. Imagine bonding metal plates together instead of bolting or welding them. That is not an easy job though, particularly if the binder should not be toxic.

The solution could very well be a molecular nano-adhesive which binds two materials together with an almost unbreakable chemical adhesion.

"Rubber is usually bonded to metal via a standard kind of adhesive that's quite toxic, not very reliable, and not very durable. That's a big issue, first of all because of the toxicity – we want clean products. So the idea is to develop a new kind of adhesive on a molecular level using covalent bonding – without any third material. In essence, we're trying to bond the rubber directly to the metal by means of chemistry in an effort to develop a clean, reliable product without any toxicity issues. From our mechanical engineering perspective, the challenge comes from another fact: rubber and metals lie on opposite sides in terms of elastic properties. Once they are bonded together, such a material mismatch leads to severe stress gradients," says Assistant Professor Michal Kazimierz Budzik.

Developing special molecules

Molecules have different electrical charges in their chemical structure. This leads to van der Waal forces – relatively weak repulsive or attractive forces that occur between atoms of different materials. Ordinary adhesives stick to materials using weak attractive forces and can then bind the materials together when they have cured.

In comparison, covalent bonds are considerably stronger, and do not have the problem normal adhesives have when they come in contact with water.

"Think of the situation when the rubber and metal interface is subjected to high stress. In addition, water is one of the most aggressive environments for polymers and interfaces. Water is polar in nature, which means that hydrogen bonds can form between it and the adhesive, thereby breaking up the bond. This leads to situations such as the rubber coating in the valve becoming loose so that it gradually loses its function and provides access to bacterial growth. This is definitely not the easiest situation to deal with in mechanics," says Assistant Professor Budzik. And as if that is not enough, cleaning processes involving steam and high temperatures in industries where adhesives are used can easily destroy the bond line between 'glued' materials.

Aarhus University researchers therefore aim to develop special molecules that form chemical bonds with a metal surface and then adhere to rubber using surface-grafted polymer brushes – a recent nanotechnology breakthrough in binders.

Considerable potential

Through an electrochemical process and polymerisation on the metal surface, this surface-bound polymer layer is combined with the rubber. The combination creates chemical bonds criss-crossing among the polymer chains in the mixture, including the surface-bound polymer layer, which thus acts as the adhesive between the metal and the rubber. It ensures an incredibly strong bond and a variety of desirable effects.

For example, scientists forecast that material/adhesive consumption can be reduced by a factor of 1,000, and that food industry safety will be significantly increased.

So far, the researchers have managed to bond rubber to metal using the novel formulation. A big milestone. However, there is still a way to go before such a molecular adhesive is validated and ready for use.

Photo: Lars Kruse

project facts

TITLE
Molecular Adhesive for Strong and Durable Bonding of Rubber to Metal

SCHEDULE
2016–2019

FINANCIAL FRAMEWORK
DKK 11.9 million
Innovation Fund Denmark

PROJECT PARTNERS
AVK Gummi A/S
RadiSurf ApS

CONTACT
Assistant Professor
Michal Kazimierz Budzik
mibu@eng.au.dk

A super glue that could create an unbreakable bond between rubber and metal would have huge potential in the food and water distribution industries. Assistant Professor Michal Kazimierz Budzik (right) is working here with PhD student Simon Heide-Jørgensen (left) on discovering stress properties of just such a potential super glue.

ENERGY

Researchers are currently embarking on a new chapter in the history of energy, where we will be frontrunners for a sustainable transformation of the global climate. We will experience enormous changes in the way we produce, distribute, store and use energy. The world needs new technologies that can ensure a sustainable and intelligent energy supply, integrating sources such as solar energy, wind, hydrogen and biomass.

Green power for Apple's new data centre

Researchers will help Apple to create a stable supply of sustainable energy for the first stage of the 250,000-square-metre data centre opening in Denmark in 2017.

Beginning in 2017, Apple's new data centre will store enormous amounts of information from some of the large online services we know, including iTunes, iCloud and App Store. Once completed, the centre is therefore expected to have an energy consumption of approximately 2000 gigawatt hours, which is the equivalent of more than half a million Danish households.

The decision to locate the data centre's activities in Central Jutland is largely because Danish researchers have internationally competitive technology insight and expertise in developing and implementing green power that is 100 per cent reliable round the clock.

In addition, Aarhus University can offer a location that is a hub for electricity transmission in the Nordic countries, and this makes it possible to balance the power supply between Danish and German wind turbines and Norwegian hydropower.

App Store, iTunes and iCloud round the clock

Associate Professor Lars Ditlev Mørck Ottosen is the research director for Aarhus University's collaboration with Apple, and he estimates that the American investment in Danish knowledge can be a boost for market maturation and the capitalisation of many new technology projects in the biomass and sustainable energy industry.

"Our job is to develop concepts that can ensure a stable supply of electricity for Apple based on fluctuating energy sources, and this means that we have to find new methods to store power. It's a huge research-related challenge for us and also a unique opportunity to create new knowledge and even more business collaboration, thereby boosting our national expertise in energy technology," says Associate Professor Ottosen.

Fossil fuels or nuclear power are currently the only alternatives available for a completely stable supply of power in the amounts required for round-the-clock operations for App Store, iTunes and iCloud. In recent years, however, Aarhus University researchers have achieved a number of interesting results in their work with storing surplus power from wind turbines, and one of the solutions to this is biotechnology.

"Science has been trying for several years to find appropriate solutions to how to store volatile solar and wind energy. We now have very positive experimental experience with microbial methanation, and we therefore estimate that biotechnology can play a significantly more far-reaching role in the transition to a sustainable energy society," says Associate Professor Ottosen.

Natural gas grid – a gigantic battery

Researchers fed a certain type of bacteria in the laboratory with water, electricity and carbon dioxide, and got them to produce methane gas – a stable energy carrier that can be integrated in the natural gas grid. According to Associate Professor Ottosen, the method can play a key role in Apple's energy supply.

"Now that we've demonstrated how to use microbiological techniques to convert surplus power from wind turbines to methane gas, it's also likely that we can create the necessary storage capacity that Apple wants. In the coming years, we'll study in much greater detail how we can use the natural gas grid as a gigantic battery," he says.

The researchers expect that the new method for producing methane gas can be put into practice within a few years. They have also carried out the first suc-

Photo: Anders Trærup

The iTunes, iCloud and App Store servers will eventually run on supplementary power produced by Aarhus University researchers. They will use the surplus power from wind turbines to produce large amounts of methane gas. They will store the gas in the natural gas grid and convert it to electricity as required to run Apple's new data centre in Denmark. Photo: Associate Professor Lars Ditlev Mørck Ottosen.

cessful full-scale experiments with methanation of biogas at the university's large research facility at AU Foulum. They are concurrently working with modifications to the living conditions of the hydrogen-eating bacteria in tanks, in the hope of turning them into super-efficient producers of stable energy carriers.

The researchers are now about to reveal precisely how the microbiological system works and how they can get them to produce methane in an economically viable way.

New fuel cells convert gas to electricity

The researchers have been awarded a grant of DKK 21.5 million for the first four stages of the university's collaboration with Apple. In addition, Apple is contributing with new knowledge about fuel cell technology, which can benefit the entire Danish biogas industry.

"The plan is that the large amounts of methane from wind turbine surplus power should be converted to electricity as required," explains Associate Professor Ottosen.

"In recent years, Apple has invested heavily in research into fuel cells, and therefore has very detailed knowledge about how we can convert biogas to power. We can therefore work together to provide Apple with a sustainable energy supply that is not only technologically innovative, but also financially beneficial. In principle, it's a case study that can provide Danish know-how with a boost in biogas and storage technologies," he says.

The researchers' plan to convert gas to electricity will provide superior storage capacity, while it is still a challenge to achieve an efficiency that can match the existing battery technology.

Today it is not yet possible to store energy from wind turbines. Whenever there is a surplus, it is therefore sold to the electricity companies at a low price.

project facts

CONTACT

Associate Professor
Lars Ditlev Mørck Ottosen
ldmo@eng.au.dk

Danes use less energy on heating

Researchers have surveyed the district heating consumption of as many as 28,000 Danish single-family houses. They can thus for the first time document development in the actual energy consumption for heating private homes in Denmark, and conclude that new cost-cutting measures in the current building regulations do work.

project facts

TITLE
Data visualisation of the district heating consumption of the Danes. Part of Resource Efficient cities implementing ADvanced smart citY solutions (READY)

SCHEDULE
2016–2017

FINANCIAL FRAMEWORK
EUR 33 million
EU´s 7th Framework Programme for Research

CONTACT
Associate Professor Steffen Petersen, stp@eng.au.dk

With extensive data visualisation of the district heating consumption of single-family houses, researchers can now for the first time document Denmark's real energy demand for heating homes.

"We can see a clear correlation between the age of the buildings and the actual energy consumption with a very significant decline starting with houses built in the 1950s. This means that we now have an empirical overview that makes it possible to document the impact of historical energy-saving requirements in the building regulations," says Associate Professor Steffen Petersen.

The researchers closely studied district heating consumption in the last three years for a total of 28,000 single-family houses built in the period from 1900 and up to 2012. Using information from the national Building and Housing Register (BBR) and smart meter data for the individual households, they succeeded in showing average consumption in time-related development.

It has not previously been possible to document the real effect of legislative energy requirements for houses.

Energy requirements in the building regulations do work

The Aarhus University researchers worked closely on the extensive data analysis with AffaldVarme Aarhus (Waste and District Heating Aarhus) – one of Denmark's largest district heating providers. Based on the results, they can conclude that the increased energy requirements in the 2006 building regulations have had a particularly positive effect.

During the period from 2006 to 2011 alone, heating consumption in single-family houses fell by 25 per cent, which corresponds to the political ambition of the specific requirements.

"Our study provides solid documentation for the increased energy requirements having an impact on the actual household energy consumption. It's clearly shown in the data that one of the most ambitious initiatives ever undertaken to tighten energy requirements in the building industry has had the desired relative effect on the actual energy consumption of single-family houses," says Associate Professor Petersen.

In research circles, the increased energy requirements in the building regulations have been a topic of great discussion since they were introduced.

Even though the comprehensive analysis of district heating data shows that the average energy consumption for heating homes depends on the specific energy requirements in the year of construction, the researchers can nevertheless ascertain that there is significant diversion in each construction year.

"When we consider the average district heating consumption in the building stock, it appears as a clear function of the year of construction. If we take a slightly more detailed approach, however, we can see that there are very large variations in the energy consumption in otherwise comparable single-family houses," says Associate Professor Petersen.

Considerable difference in heating consumption in houses with the same energy label

Part of the explanation of this large diversion can be variations in the number of household occupants and different preferences regarding comfortable room temperatures. According to Associate Professor Petersen, however, high energy consumption can also be due

to faults and defects in the construction work.

"In newer houses, energy consumption at the high end of the scale can possibly be caused by an insufficient building envelope, poorly regulated ventilation and heating systems – and even shoddy work and negligence," he says.

The difference between the estimated and the measured energy consumption is most pronounced in newer single-family houses, and this gives rise to checking the existing calculation methods in the building trade.

"It's a big problem. We have to take a closer look at the methods and standards used by engineers when they're calculating a household's energy consumption while the building is still on the drawing board. It should be such that both homeowners and utility companies experience that theory matches reality," says Associate Professor Petersen.

In the time ahead, the researchers will collaborate with AffaldVarme Aarhus to identify the exact causes of the large diversion in the household energy consumption. This will also provide new knowledge about opportunities for optimising district heating operations.

"We're in the process of analysing household energy consumption for heating on a weekly, hourly and minute-by-minute basis, and then it's likely that we can point out how we can optimise district heating operations and the pipeline network. We'll also take a closer look at how we can make the energy calculations in the current building regulations more accurate for the actual operations. Our aim is to create an evidence-based foundation for decisions about future investments," says Business Developer Adam Brun, AffaldVarme Aarhus.

Photo: Lars Kruse

With energy data from 28,000 single-family houses in Denmark, Danish researchers document that the current energy requirements for new houses have a significant and positive impact on heat consumption. Shown here are Associate Professor Steffen Petersen (right) and PhD student Martin Heine Kristensen (left) who are responsible for the study.

Overloaded: How to save the green energy network of tomorrow

The energy network of the future will be much more decentralised than at present, where large heat and power plants provide the coverage. This can potentially overload local grids that are not designed for the modern form of energy production. Flow batteries can be the solution.

By 2050, Denmark will be 100 per cent independent of fossil fuels. This is a political decision and changes have already been implemented in the energy system to embrace a more decentralised structure. Total independence from fossil fuels means that citizens will become more and more dependent on electricity in the society of the future – electric cars, for example, are gradually taking over an ever-larger share of the market, and they require a connection to the electricity grid in order to run.

The future is electric so to speak, and more and more people recognise the value of producing their own power by means of sources such as solar cells on the roof. Previous subsidy schemes made this economically viable, but the regulations have been changed, and owners of solar cell panels can therefore no longer receive payment for the power they deliver to the grid. At the same time, they are only exempt from energy charges during the hours their own production is in progress.

"The reason is that solar cells have become so cheap. And this is where the need for a battery comes into the picture," says Associate Professor Anders Bentien. He is taking part in the Grid Connected Flow Batteries project which is basically about storing the power produced and releasing it at a later date as cheaply as possible.

A good alternative

Associate Professor Bentien is an expert in flow batteries, a type of battery where energy is stored in liquids that are pumped into a flow cell when it is being charged or discharged. Such batteries are typically extremely large and are often used for storing electricity from power plants. In their project, however, the researchers have scaled down the size to dimensions that are suitable for apartment buildings or housing associations, for example. The project is already prepared for the experimental stage.

And it may turn out that flow batteries are a valuable alternative for utility companies which are often equipped with old cables that are in no way designed for the fluctuating power production for today's households. In fact, many older suburban neighbourhoods from the 60s and 70s have no power line or transformer capacity at all for the large amounts of power produced by the many new solar cell panels during daylight hours when the sun is shining and people are at work.

"The plants are undersized, and we're dealing with transformer stations that are possibly totally unsuitable for transforming power the other way. This is where battery storage could be a really good alternative to digging down new cables and building new transformer stations. This is what we'll be testing in the project," says Associate Professor Bentien.

Flow vs. lithium-ion

There is nothing new in household batteries. Most people have heard of Tesla which is on the way to producing a household battery with functions that include talking to the electric car. The difference lies in the type of battery, where flow batteries differ significantly from lithium-ion batteries, for example, which are otherwise very widespread in all forms of electronics.

Photo: Lars Kruse

What do you do when the electricity grid has not been updated to cover the boost in power consumption to run both cars and heating pumps in the future? Batteries can be the way forward, according to Associate Professor Anders Bentien.

"What has been the driving force behind battery development for many years is the pursuit of higher energy density. We wanted batteries for mobile phones or laptops to be smaller and last longer. There's no doubt here that the lithium-ion batteries are leading, but the problem is the price. In terms of mobile phones, this doesn't matter so much, but when it comes to storing energy from energy production, it's another matter altogether," says Associate Professor Bentien.

Here price can actually be more important than energy density, especially when it comes to large-scale storage – i.e. storing energy from large stationary applications such as solar cells or wind turbines.

"The energy density of flow batteries can be a factor of 3–5 times less than lithium-ion batteries. So they take up somewhat more space, but the price is significantly lower in return," says Associate Professor Bentien.

"What's interesting for an end-user is something known as the levelised cost of electricity storage. This means the price you pay to store one kWh and get it back again, where the service life of the battery is one of the factors taken into account. In this way, lead batteries score relatively high because they don't withstand very many discharges," he continues.

Lithium-ion batteries also have a relatively high levelised cost of electricity storage because they are so expensive to buy. Flow batteries, on the other hand, are relatively cheap to buy and are very durable because, in principle, the liquid used has an endless lifespan and can be recycled.

project facts

TITLE
Grid Connected Flow Batteries

SCHEDULE
2017-2019

FINANCIAL FRAMEWORK
EUR 1.2 million
Energy technological development and Demonstration Program (EUDP)

PROJECT PARTNERS
Eniig (Energi Midt)
VisBlue

CONTACT
Associate Professor Anders Bentien
bentien@eng.au.dk

Developing the bio-boilers of the future

Straw-fired boilers are used all over Denmark to provide heating for homes and farm buildings, but they create much more pollution than comparable wood pellet boilers. A new project will try to amend this because straw is a very inexpensive form of fuel, and the prospects are therefore considerable for farming and small heating plants.

Photo: Anders Trærup

Straw-fired bio-boilers have undergone tremendous development since they took over much of the heat production in farming during the 1970s. But there is still a long way to go to catch up with ultra-modern wood pellet boilers. Shown here are Erik Fløjgaard Kristensen (left) and Jens Kristian Kristensen (right), a technician in the biomass heating laboratory. They are both working on optimising the straw-fired boilers of the future.

The annual harvest is a recurring sign of the arrival of autumn in Denmark, where heavy combine harvesters slowly transform the golden-brown landscape into stubble fields dotted with large rectangular bales of straw. This is nature taking its course, and is just as certain as the leaves beginning to fade at this time of the year. But what actually happens to the bales of straw?

In the old days, straw was used as feed and bedding – for filling in beds and for thatching roofs. Nowadays, there are new application options such as straw insulation in experimental concrete buildings. In connection with the oil crisis in the 1970s, straw was also gradually used for fuel on many farms in simple straw-fired boilers. Just like wood, straw is regarded as a carbon dioxide-neutral fuel. And all over Denmark, especially in farming and small decentralised combined heat and power (CHP) plants, straw-fired boilers are used today to provide hot water in taps and radiators.

However, such boilers have developed significantly since the early 1970s. From being simple ovens that most of the time spewed out black and foul-smelling smoke from the chimneys, straw-fired boilers today are ultra-modern fuel boilers with a degree of efficiency close to 90 per cent, where it is hard to see by looking at the chimney whether the boiler is turned on or off.

Minimising emissions

However, this does not mean that the combustion cannot be improved and emissions reduced even more. It is actually a really good idea because low environmental impact from burning has become a very important competitive parameter since green energy and sustainability became buzzwords. In addition, strict emission requirements for solid fuel boilers, as described in the Executive Order on wood-burning stoves, will apply to all new straw-fired boilers after January 2018.

Alcon – a company in Central Jutland that develops, manufactures and sells straw-fired boilers – is therefore collaborating on a project with researchers at the Foulum Research Centre, Aarhus University, to make the company's most efficient straw-fired boiler even better.

"The idea is to develop the most environmentally responsible portion-fired straw boiler on the market. With a starting point in the market's best degree of efficiency, we now want to see how we can combine this with the lowest possible emission of environmentally hazardous substances such as carbon monoxide (CO), hydrocarbons and dust particles," says Erik Fløjgaard Kristensen.

And there is good use for this. Product development of the smaller, portion-fired straw boilers has actually been at a standstill ever since 2001 when the Danish Energy Agency abolished the subsidy scheme for small biofuel boilers that had been introduced in 1995 to ensure improved efficiency and lower emissions from precisely this type of boiler.

This generally means today that portion-fired straw boilers still pollute with more CO and other unburned flue gases than automatic straw stokers, and even more compared to wood pellet stokers. And because these emissions can contain carcinogenic hydrocarbons (PAHs), there is a need to improve combustion in these types of boilers.

The right temperature is critical

An important parameter as regards reducing CO emissions and unburned hydrocarbons is the temperature in the boiler's combustion chamber. If the temperature is too low, the hydrocarbons in the flue gases are not burned well enough. However, if the temperature is too high, it can exceed the melting point of the ash, which can result in problems such as increased emissions of fly ash. Straw normally contains some salts and minerals that can evaporate from the melting ash and condense into a very fine-grained dust – fly ash – when the smoke is cooled on its way out of the boiler.

The temperature must therefore be highest at the top of the combustion chamber, where the flue gases accumulate, and lowest at the bottom, where the ash is deposited. There must also be the right mixing ratio between the amount of flue gases and the amount of combustion air supplied, which is achieved by an electronic control box automatically regulating the amount of primary and secondary air by increasing or decreasing it in relation to the oxygen content in the flue gas.

A standard boiler from Alcon was used in the first stage of the project and, based on experience with this boiler, a new one has been built with a number of improvements. The researchers expect that the new boiler will be able to reduce CO emissions so much that the boiler can comply with future limit values.

project facts

TITLE
Optimising combustion in a portion-fired straw boiler

SCHEDULE
2016-2017

FINANCIAL FRAMEWORK
DKK 1.4 million
Innovation Fund Denmark

PROJECT PARTNERS
Alcon A/S
ChimneyLab Europe ApS
Eurofins Danmark A/S

CONTACT
Erik Fløjgaard Kristensen
erikf.kristensen@eng.au.dk

How do you distinguish renewable energy?

Are you buying certified green power? Then perhaps you have wondered whether you are actually getting what you are paying extra for. Because how do you tell electricity apart?

Green, sustainable and renewable energy is in and has been for years. Land-based and offshore wind farms are popping up everywhere, and house owners across the globe are looking to invest in solar power, where deployment has soared since the early 2000s. The worldwide growth of solar cell power, for instance, has averaged 40 per cent per year since 2000 and reached a total capacity of 253 terawatt hours (TWh) in 2015.

That is a lot of green power from a considerable number of different places flowing into a grid infrastructure designed and optimised for centralised power generation – the fossil-fuel based system that the European power grid relied on in the past. So how do you distinguish where the power is coming from?

Postdoctoral Fellow Mirko Schäfer is working on exactly that problem in a project funded by the Carlsberg Foundation.

"Think of it as a big pool that everyone is putting power into and taking it from again. Once you put power into the pool or take power out, there's no telling where it came from. You can't put a stamp on the power to show you where it originated and who profits from it. It's very hard to distinguish who's actually using certain parts of the grid infrastructure," he says.

Complicating the complicated

The ever-increasing number of micro-contributors – such as a single family house with solar cells or a single wind turbine – makes an already complex grid system even more complicated. And it becomes still more complex because, even though the pool analogy may sound simple, it is actually far from reality.

"You have a specific grid infrastructure and there are limits on it. Only a certain amount of power can be transmitted because, otherwise, the infrastructure might break down. An example is the grid between northern and southern Germany, where the infrastructure is not large enough to accommodate the flow of power required," explains Mirko Schäfer.

So in a world in which an increasing number of private individuals, companies and publicly owned energy farms contribute to a failing grid, who is paying? And how can you be sure that you are actually getting the 'certified green power' that you might be paying for explicitly if energy cannot be marked?

The solution is flow tracing and, if we return to the pool analogy, it is just like adding colour to the water.

"You can't distinguish one drop of water from the next. But what you can do is 'colour' it at its origin. You can trace the energy through the grid by looking at its origin, the origin's data and flow pattern. That way you can tell who's injecting how much at what place and what time. The result is a pool of different colours, and that way you can distinguish the flow algorithmically," says Mirko Schäfer.

Ensuring the right price

An example could be offshore wind farms, where a large percentage of the generated energy is not used by the country that creates it – the country where the wind farm is located. Flow tracing can then be used to allocate some of the investment cost and the cost of producing the energy to the countries that are actually buying the energy from the particular farm.

This way the cost of the future power grid – which is dependent on long-range power transmission, storage, back-up power generation units, etc. – can be more fairly distributed between those who actually use the power and the general public, who up until now have usually borne the cost of grid inefficiencies.

Photo: Lars Kruse

Flow tracing is becoming more and more necessary as a means of control in a decentralised energy grid such as the one we are heading towards as a society. Photo: Postdoctoral Fellow Mirko Schäfer

project facts

TITLE
Tracing the power flow in complex renewable energy networks

SCHEDULE
2016-2018

FINANCIAL FRAMEWORK
DKK 1.1 million
The Carlsberg Foundation

CONTACT
Postdoctoral Fellow Mirko Schäfer
schaefer@eng.au.dk

Smart transition will ensure green energy by 2050

Denmark will be 100 per cent independent of fossil fuels by the year 2050. Already now, we must rethink the transformation of our energy system, and link electricity, heating and transport in a smart way. Not only Danish but also European energy companies must be involved. A major new project will pave the way.

project facts

TITLE
RE-Invest – Renewable Energy Investments Strategies – A two-dimensional interconnectivity approach

SCHEDULE
2017–2021

FINANCIAL FRAMEWORK
DKK 27 million
Innovation Fund Denmark

PROJECT PARTNERS
Aalborg University
Stanford University (USA)
Frankfurt Institute for Advanced Studies (Germany)
Østfoldforskning (Norway)
DONG Energy
Energinet.dk
Danish Energy Agency
HMN Naturgas
Haldor Topsoe
EMD International
Statkraft
Danish District Heating Association
Danfoss
Kamstrup
Aalborg CSP
MP Pension.

CONTACT
Professor Martin Greiner
greiner@eng.au.dk
Assistant Professor Gorm Bruun Andresen
gba@eng.au.dk

In a few years, Denmark will be at a turning point where new methods are required to continue the green transition. Approximately 50 per cent of all Danish electricity will soon come from wind, and Denmark has solved the enormous challenge of getting power plants to increase or decrease electricity production in response to changing wind conditions. The next problem is to exploit wind, solar and biomass energy for heating production, and especially to keep the wheels turning in the transport sector which is heavily dependent on fossil petrol and diesel. A political decision has been taken that Denmark should manage with no fossil fuels at all by 2050 – and we will have reached 30 per cent of this target by 2020.

To reach the final target, a complete reorganisation of the entire energy grid is necessary, so this must already be incorporated into the future strategy. The decisions and investments we make now regarding energy, heating and transport services can be crucially important for when the political finishing line is reached.

"If we build a new power plant today, we're locked into this technology for 40 years. That's about as long as such a plant can last. The new things we build today must therefore fit into both the present and the future, so that the transition to clean renewable energy in 2050 can take place as smartly and cheaply as possible. It's really a matter of converting to what is right without forgetting the whole energy infrastructure we've got today," says Assistant Professor Gorm Bruun Andresen.

More dependent on electricity than ever

Gorm Bruun Andresen is participating in the RE-Invest project which gathers some of the major players in the energy market that are joined by researchers from some of the leading universities in the world. This is because it involves much more than simply replacing coal-fired power plants with wind turbines.

The energy system of the future will actually be far more decentralised than it is today. Wind turbines and solar cells are making greater and greater inroads, and this means that the system must be able to handle varying energy production. At the same time, our everyday activities are becoming significantly more dependent on electricity for basics such as heating and transport, which means that the system must be capable of dealing with and

Photo: Lars Kruse

Solar and wind energy will cover an ever-greater share of Denmark's power supply, and this means that the network must be able to handle a decentralised energy structure with fluctuating production. Pictured here are Assistant Professor Gorm Bruun Andresen (left) and Professor Martin Greiner (right), who will both help steer Denmark towards the right investment strategy that will make the country free of fossil fuels by 2050.

benefiting from an overall energy infrastructure rather than the traditional silos of electricity, heating and transport.

In addition, as we all know, wind turbines and solar cells work best when weather conditions permit. Denmark's electricity system of the future will therefore become dependent on our neighbouring countries, which means we must look beyond our borders when we talk about energy production in the future.

"We must keep Europe in mind. Denmark has one strategy, but how does that fit in with the rest of Europe? How do the decisions taken in other countries influence the Danish model with lots of wind, for example? The electricity grid must match so that when we have excess wind, and thereby produce surplus energy, it's no use that all the other surrounding countries are also producing too much wind energy. It involves coordinating our strategy with all the others," says Professor Martin Greiner, who is also taking part in the project.

Getting a technological head start

Green conversion and phasing out fossil fuels are not cheap. They actually require an annual investment of approximately DKK 100 billion because the transition involves not only energy and heating but also the entire transport sector, including cars that run on diesel and petrol. However, if Denmark leads the way with the development, the players in the Danish energy sector can make use of the technological head start resulting from such a green transition.

"If Denmark takes the lead, this is where the solutions will be developed and tried out, and our companies will learn from it. It's not so many years ago that half of all the wind turbines in the world were situated in Denmark. In other words, the experience gained in building such constructions is located in Denmark. This is one of the things we get by taking the lead. It might be expensive but, on the other hand, we acquire experience we can sell to the rest of the world," explains Assistant Professor Andresen.

Navitas Campus, Aarhus

Photo: Maria Randima

HEALTH

Global demographic development puts considerable strain on health services in all communities. Technology is one of the most important drivers for a health sector that can ensure quality of life for even more of the world's population. In the years ahead, engineers will be involved in developing areas such as digital medicine, new forms of diagnosis and treatment, artificial organs and technology-based surgery.

Mathematical models behind new cancer images

By combining two different scanning technologies, researchers have succeeded in creating completely new and detailed images of cancer tumours in mice. This could eventually pave the way for the development of more effective drugs.

A Danish research team is behind a new method for studying how a tracer is distributed in a cancer tumour via its extensive vascular network.

The method can be used for purposes such as closely studying the effect of medical treatment using cancer inhibitors.

By means of mathematical modelling, the researchers combined two previously known scanning technologies – magnetic resonance imaging (MRI) and computed tomography (CT) – and used these to study tumours in laboratory animals.

This resulted in completely new images at very high resolution, which provide detailed mapping of the branching of tumour blood vessels.

"We can lay two images of the same cancer tumour on top of each other so to speak, so we get a more geometrically complex understanding of the individual tumour's blood vessels, and thereby an opportunity to very precisely study the way drugs are distributed," says Associate Professor Jens Vinge Nygaard.

He is responsible for the mathematical modelling work for the imaging, and he expects that the method could ultimately be used to develop new drugs and optimise dosing for the individual patient.

15,000 blood vessels under the microscope

An MR image can show how a tracer used as a cancer-inhibiting drug is distributed inside the tumour, but only in a relatively coarse resolution.

An image from a micro-CT scanner, on the other hand, can show an extensive network of blood vessels in the tumour at very high resolution, but it is unable to identify how the drug is transported locally.

The combination of the two imaging technologies can thereby provide significantly improved scanning images of cancer, which can play an important role in developing new drugs.

"The new images give us an opportunity to follow the way a tracer travels through the blood vessels in the tumour and into the surrounding tissue to the cancer cells. As scientists, we're interested in mapping the size and branching of the blood vessels, and understanding what goes on between the blood vessels over time. This can provide us with more detailed insight into specific treatment needs," says Thomas Rea Wittenborn, who is a cancer researcher at the Department of Experimental Clinical Oncology, Department of Clinical Medicine, Aarhus University Hospital.

The tumours they studied measure approximately 200–300 cubic millimetres and typically contain 15,000–20,000 branches of blood vessels.

Computer models replace experimental animals

The researchers followed a total of ten mice with tumours on their feet, and used the two scanning technologies to develop a computer model for each of these.

In principle, the models form the foundation for a completely unique experimental platform.

"Using the computer models, we've created a virtual experimental platform so to speak, and can thereby considerably extend our experiments because we're not dependent on experimental animals. In practice, we can sit in front of our computer screens and study what happens to the tumour if we use drugs that stay in the tissue for longer or shorter periods, or are adapted for small or large blood vessels," says Associate Professor Nygaard.

In the time ahead, the researchers will expand their experiment with more mice and follow the cancer tumours over a period of time. This will provide them with an opportunity to develop computer models that not only describe drug distribution in a static stage of the cancer process, but also generate precise growth scenarios for cancer tumours.

"Using the new imaging method, we'll be capable in purely mathematical terms of predicting tumour development in connection with different drug strategies," says Associate Professor Nygaard.

project facts

CONTACT
Associate Professor Jens Vinge Nygaard
jvn@eng.au.dk

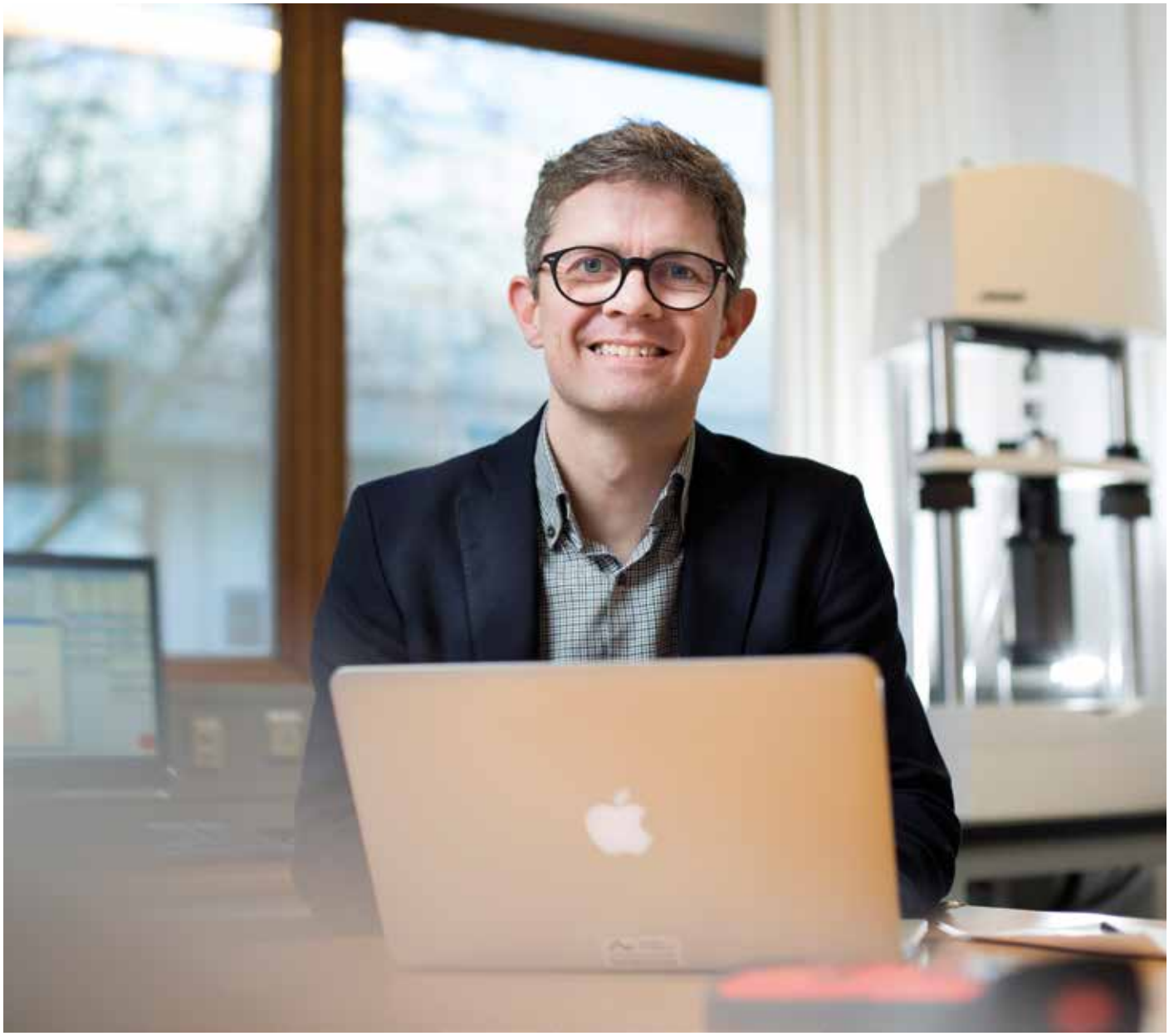


Photo: Lars Kruse

Associate Professor Jens Vinge Nygaard specialises in classical mechanics. Using mathematical models, he can predict the development of a cancer tumour.

project facts

TITLE
Prometheus

SCHEDULE
2016–2018

FINANCIAL FRAMEWORK
DKK 9.5 million
EU Interreg

PROJECT PARTNERS
University of Southern Denmark (SDU)
Little Belt Hospital
Kiel University Hospital

CONTACT
Professor Peter Gall Krogh,
pkrogh@eng.au.dk

Design provides better patient care

A new design tool will make it easier to individualise technology for self-monitoring and thereby motivate patients to take a far more active role in their own treatment. Researchers are carrying out the first pilot studies on Danish patients in a urology ward.

Chronically ill patients are now, to a large extent, co-responsible for maintaining a lifestyle and regulating behaviour that has a positive impact on their own symptom development. Examples of this could be following a plan for medication intake, complying with dietary recommendations, maintaining a sleep pattern, and increasing the level of physical activity.

The hospital sector is to an increasing degree implementing technology-based self-monitoring with a view to helping patients maintain health-improving activities and habits.

No complete documentation is yet available for the effect of a patient's technology-based self-monitoring, and researchers are therefore taking a closer look at the correlation between measuring devices and symptom development.

In an international project, they are studying the design of the actual measuring devices as well as the importance of the design regarding how patients record their activity, how they experience their state of health, and the interpretation of data by health personnel.

"People used to be sent home from hospital with a pamphlet on how to deal with their illness. Practitioners now have far more focus on teaching individual patients to master their illness by means of appropriate habits. Preliminary studies here show that self-monitoring can be crucial for lifestyle changes. The challenge is that patients are different, and the self-monitoring devices should therefore optimally be designed based on individual needs and preferences in terms of both technological interaction and physical design," says Professor Peter Gall Krogh.

The researchers are also studying areas such as how the design of the self-monitoring devices can address the physical condition and technological insight of the patients.

Stronger motivation for self-monitoring
To meet individual preferences regard-

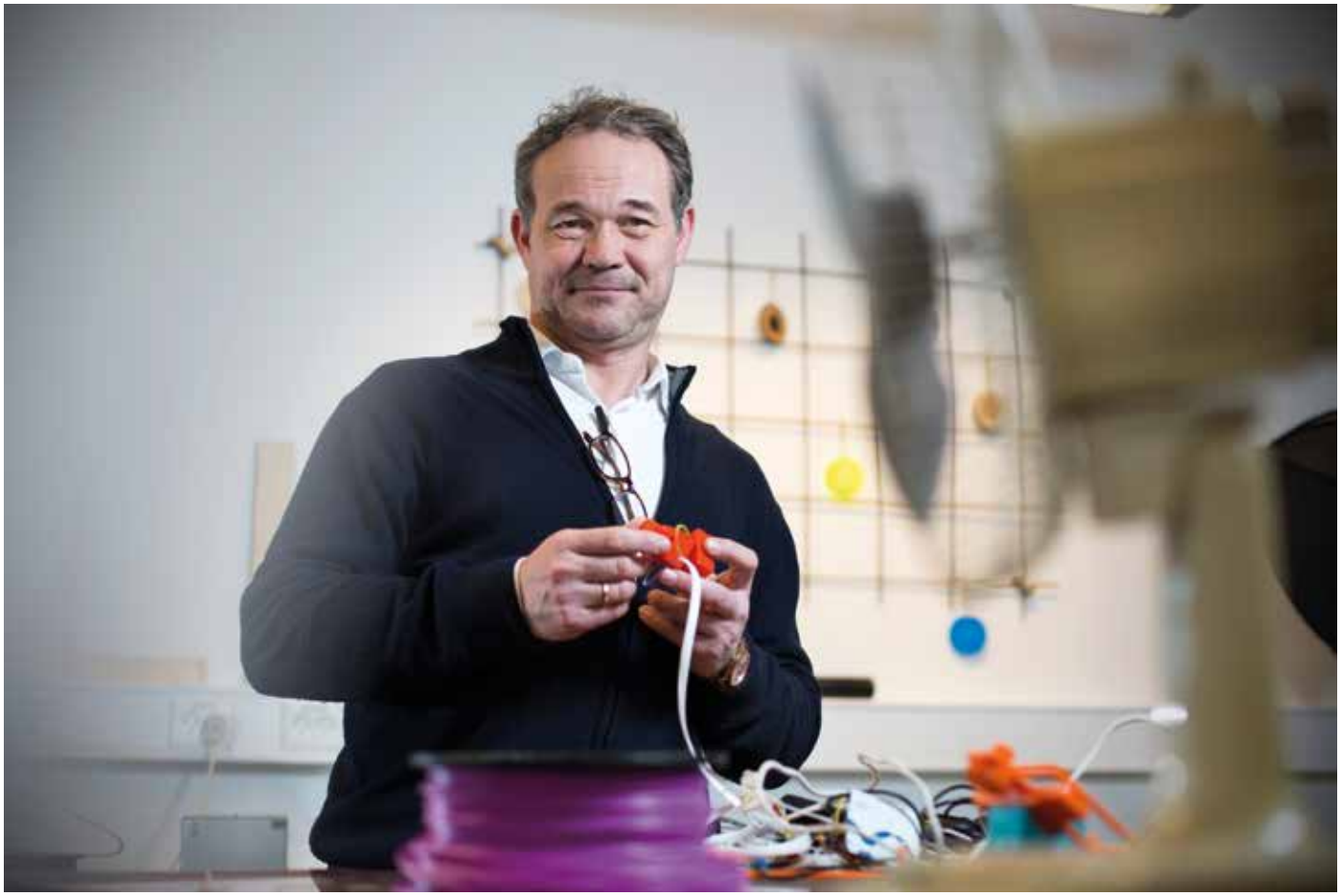


Photo: Lars Kruse

Design can prove to be considerably more important than previously thought for the self-care of chronically ill patients. Professor Peter Gall Krogh is developing new sensor-based prototypes of self-monitoring devices that will help urology patients.

ing self-monitoring, the researchers in the project are working on developing a design tool and a number of sensor-based prototypes that can communicate in different ways with external wireless units and networks.

"Doctors would like their patients to regularly record any pain they experience or their fluid intake, etc. But how does this work best? For one patient, it could be entering a numeric value on a smartphone. However, it could be something completely different for another. Hospitals today use more or less randomly selected standard electronic devices. Our hypothesis is that we can achieve far better results with self-monitoring if the selection of the measuring units is based on the individual patient's preferences, prerequisites and user context. It's a matter of integrating technology development, patient care, and design thinking," says Professor Krogh.

Increased fluid intake among renal patients

In the first stage of the pilot project, the researchers' sensor-based prototypes will be tested by practitioners and kidney stone patients at the Department of Urology, Little Belt Hospital. The project will specifically demonstrate aspects such as the effect of custom-designed sensors and healthcare wearables as regards increasing fluid intake in patients.

A patient with kidney stones must drink at least six litres of fluid per day to reduce pain in connection with urination.

"The question is how to get a self-monitoring device to work that can motivate individual patients to drink so much water and remember to record their fluid intake? Should it be a wristband, a handle, an iPad or a stone in their pocket? It's a question of designing prototypes based on a deep understanding of the individual person's relation to technology," says Professor Krogh.

There is much more to lighting than flicking a switch

More and more building owners and designers are trying to adopt circadian lighting concepts for both new and retrofitted buildings. This has the potential to positively affect human behaviour, sleep and productivity.

project facts

TITLE
Lighting Solutions for Treatment of Bipolar Disorders in Psychiatric Health Care Environments

SCHEDULE
2015-2017

FINANCIAL FRAMEWORK
DKK 250,000
Innovation Fund Denmark

PROJECT PARTNERS
Dansk Energi Management & Esbensen, Moto Muto

CONTACT
Professor Werner Osterhaus
werner.osterhaus@eng.au.dk

Light – one of the most important aspects of human life and the reason for every living creature on Earth.

Ever since the invention of the incandescent light bulb in the 19th century, the lighting of building interiors has often been taken for granted as a quintessential part of our private and professional lives. But lighting today is much more than flicking a switch when you enter your office on Monday mornings.

Today scientists aim to use lighting to curb and affect the circadian rhythm – the 'built-in clock' that the human brain and body use to regulate biological processes and behaviour. There is clear evidence that particular lighting solutions with specifically targeted spectral properties can enhance the quality of sleep, while others can improve alertness and thereby perhaps human productivity. When exposed to a light stimulus, the human body reacts in different ways, for example by suppressing the sleep hormone melatonin. Similarly, lighting can be used to affect our feelings, our perception of our surroundings and our overall well-being.

Daylight, the light under which humanity has evolved, provides the most effective circadian lighting. Many of the electric lighting systems sold as circadian lighting today try to mimic daylight, but usually without its full variability.

That is why many new hospitals, homes for the elderly, office buildings and even schools that are currently being developed throughout Denmark try to adapt some form of circadian or biologically effective lighting.

Tuning the light to match the research
One of these is the Risskov Psychiatric Hospital, where scientists from Aarhus University and engineers from DEM-Esbensen are working with the medical staff to develop and test suitable lighting systems aimed at reducing the use of medication and physical restraints in the treatment of patients with bipolar disorders. With the upcoming move of the psychiatric unit to Skejby, the old Risskov hospital serves as a test bed to ensure that effective and appropriate lighting systems can be installed in the new hospital environment at Skejby.

"In collaboration with DEM-Esbensen and Moto Muto, we have created a lighting system that allows us to tune the spectral composition of the light in various ways, so that we can connect it with medical research on how lighting affects psychiatric patients. We have simultaneously studied the impact of lighting on other things than health," says Professor Werner Osterhaus.

For instance, the researchers have examined how different spectral distributions in lighting affect people's perception of space and colours in the room. Does the room feel big or small, is it comfortable to be in, or is the lighting somehow disturbing because of its spectral distribution? Can you even see things properly?

"If medical experts then find out that a specific spectrum works better than another at a specific time of day or during a particular phase in the treatment, the lighting system can be adapted to the new settings," says Professor Osterhaus.

Still no agreed-upon definition
Research in circadian lighting is still fairly new, although vigorous research since the early 1970s has shown correlations between light exposure and human emotion and productivity. In the past 15 years, medical research has developed a basic understanding of the recently discovered non-visual photoreceptors in the human eye and their functions for human health and well-being, and an understanding of how and why we react to the different spectral components in light. But there is

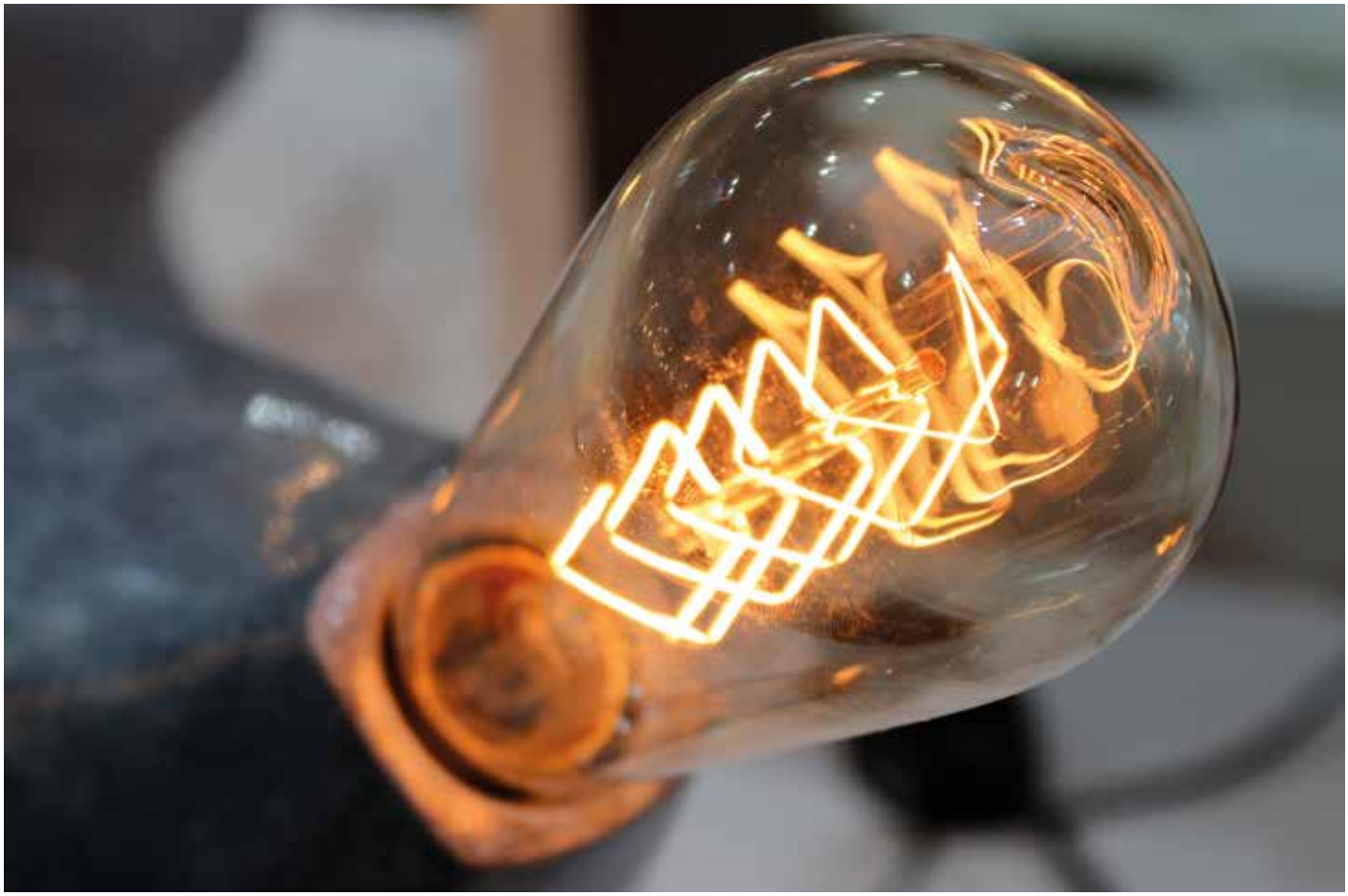


Photo: Colourbox

Incandescence – the heating of a wire filament with electricity to such a high temperature that it glows with visible light. The invention, which has been attributed to Thomas Edison, sparked a revolution fundamental to our society and way of life today.

still a long way to go, as some research suggests conflicting theories. This is why the Aarhus University researchers use adaptive systems.

"There is currently no agreed-upon definition of a circadian lighting system. And such a definition might, in fact, change depending on the situation for which it is employed. Circadian lighting is proposed in a lot of settings and with varied approaches. So it is perhaps too early to give clear recommendations for an adoption in building codes and standards. That is something we need to look at very carefully. But this does not mean that we should avoid installing lighting systems moving in this direction," says Professor Osterhaus.

"We just need to clearly state what is used in any given situation, so that we and others can assess the critical parameters and their likely impact and compare different systems. We also need multidisciplinary approaches for designing the right kind of research to further investigate circadian lighting and its impact," he continues.

Great potential for human health and well-being

Despite the increasing research evidence on the impact of appropriate lighting technology on the human circadian rhythm, it also takes time to understand the consequences and change the existing paradigms. Compared with other consumer goods, buildings have a long service life, and substantial lighting system retrofits are still rare in existing buildings. And even in new building constructions, where attempts are made to adopt new lighting technology, the result is still mostly installations with fluorescent lamps to provide the required minimum lighting levels.

"Most of the lighting systems employed in buildings today are still rather static, but some kinds of flexible systems are slowly being adopted in more and more new buildings. Systems with one correlated colour temperature, but with a dimming feature responding to the available daylight and perhaps with a control system allowing for different lighting scenarios and uses in the same room, are becoming fairly common in new buildings now," Professor Osterhaus points out.

"Well-considered lighting has a very large potential for both human health and well-being, and for reducing the environmental impact of buildings, especially when the starting point is an effective use of daylight to provide appropriate lighting levels for most of the daylight hours," he adds.

The lighting industry likes to refer to the latest technology, especially circadian lighting, as Human Centric Lighting. "But doesn't most lighting target humans?" asks Professor Osterhaus rhetorically.

"In general, engineers and architects are concerned with providing sheltered, comfortable and healthy environments for people. That is and always has been the premise we work with. Until we can make definite recommendations, however, we need to be careful not to install systems that are too rigid, but systems that are flexible enough to move with new research and adapt to it," he adds.

PRECISION AGRICULTURE

How do we ensure sufficient quantities of healthy food and clean water for a growing global population? This is one of the most acute challenges faced by the global community. At a research level, engineers are working on finding new technological solutions to ensure that we can produce more food and drinking water with fewer resources. The agriculture of the future will be based on new technology to an even greater degree than at present. In this area, Big Data, intelligent systems, robots and drones will help create automation, boost agricultural efficiency and reduce the sector's environmental impact.

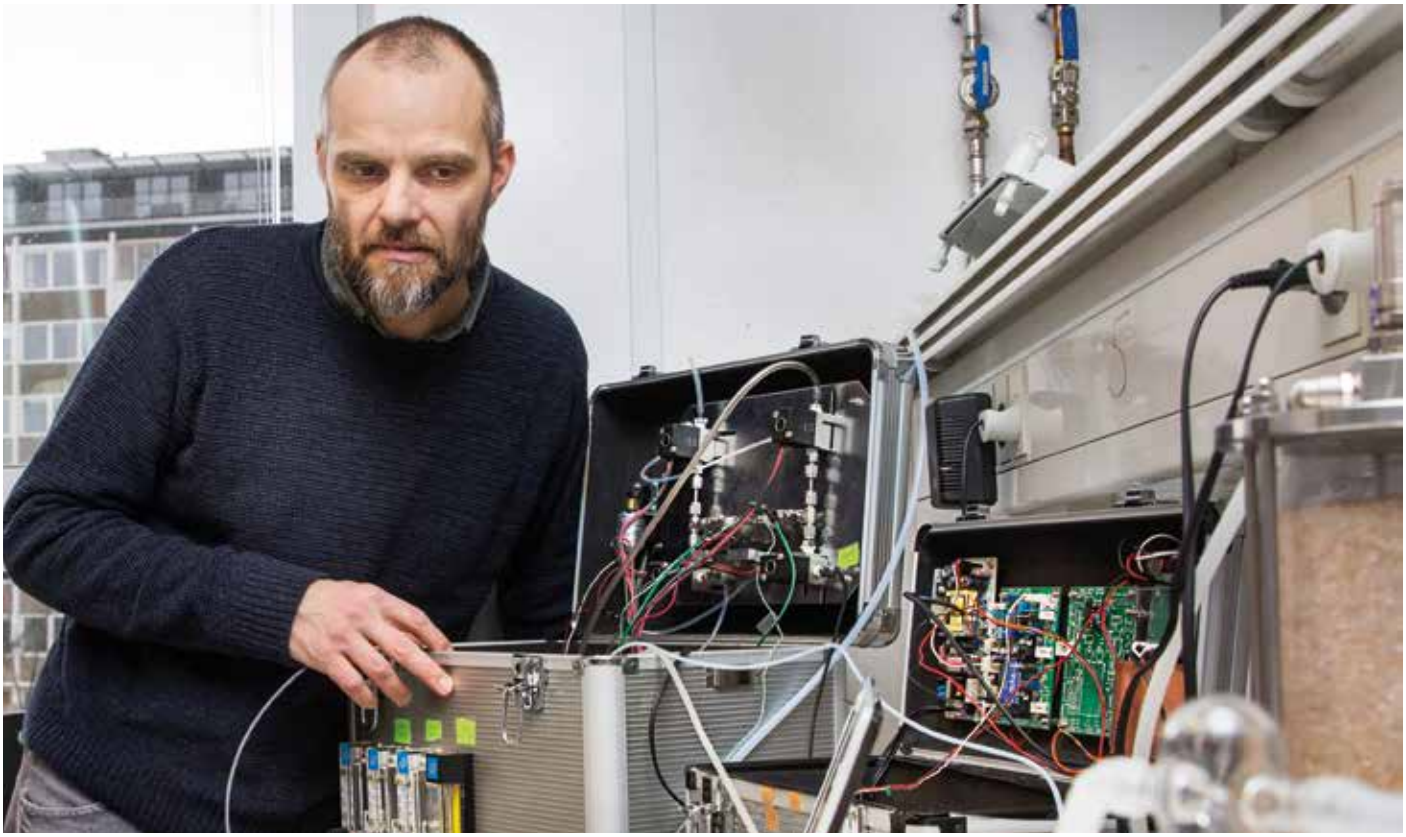


Photo: Lars Kruse

Researchers are close to a solution that provides an opportunity to monitor and limit ammonia emissions from animal housing, thereby significantly reducing the environmental impact of the farming industry. Photo: Associate Professor Anders Feilberg

New technology for reduction of air pollution from farms

Chemical technology and new sensors for purifying the air will make it possible for farmers to control ammonia emission at the same time as remediating odour from livestock production. This can contribute to a significant reduction of the total air pollution in the Western world.

Researchers will develop new technology that can very accurately measure airborne emissions of ammonia and odours from animal production facilities at the same time as retaining the pollutants.

They are focusing on ammonia in particular because it is converted in the atmosphere to particles that are harmful for humans to breathe.

"Ammonia and odours are some of the major environmental problems in agriculture, but ammonia is also a useful fertiliser if we can retain the gas. Our aim is therefore to develop technology-based methods to monitor air pollution in animal housing and limit emissions into the atmosphere," says Associate Professor Anders Feilberg.

Livestock production is currently responsible for a substantial part of air pollution in Denmark.

Chemical cleaning with great potential

In collaboration with leading Danish technology companies, the university researchers have been working on chemistry-based air purification for a number of years. On this basis, they will now develop a new technology and a finished prototype of a purification plant that can remove odours and ammonia in livestock production.

"We know that acid-base processes are effective in reducing ammonia emissions from animal housing, and we expect that a new oxidation process can also be used to remove odorous substances. We'll therefore integrate two different technologies in a chemical purification plant that can deal with large amounts of ventilation air," says Associate Professor Feilberg.

project facts

TITLE
ECOMETA (Emission Control: Methods and Technologies for Agriculture)

SCHEDULE
2017-2020

FINANCIAL FRAMEWORK
DKK 17.4 million
Innovation Fund Denmark, Grand solutions

PROJECT PARTNERS
SEGES, Agrifarm Innovation Aps
Infuser Aps
Wageningen Livestock Research (Netherlands)

CONTACT
Associate Professor Anders Feilberg
af@eng.au.dk

Photo: Lars Kruse

Several years of basic research in photonics will now benefit the farming industry. Associate Professor Martijn Heck is an expert in sensor technology, and he will develop an optical sensor that can measure the amount of ammonia by illuminating the gas with laser beams.

The new chemical technologies will work via a filter tower with different kinds of packing materials that can retain ammonia gas from the ventilation air by continuously irrigating it with different chemical liquids.

The researchers are already well advanced with their research in the laboratory. Their major engineering challenge now is to make the purification plant both reliable and economically viable.

If they succeed, this can be very important for the technology's commercialisation opportunities, according to Associate Professor Feilberg.

"We're going after an advanced chemical technology solution that can work efficiently and economically on a full scale outside the laboratory. If it works, we can expect considerable global demand," he says.

New sensors will monitor ammonia vapours and odours

In addition to designing methods for cleaning the air, the researchers will develop new sensors that can very accurately measure ammonia emissions from animal housing.

"We're working on different types of sensors, which can each in their own way record the level of air pollution with a high degree of detail. We'll also make the measuring instruments significantly smaller and cheaper in terms of design, production and operation," says Associate Professor Feilberg.

One of the sensors is optical and it will measure the amount of ammonia in the air by illuminating the gas with laser beams. The technology is based on basic engineering research in photonics that can be integrated into very small computers.

This provides farmers with an opportunity to monitor continuously, and thereby produce a time-resolved image of the pollution situation.

Another sensor is based on NMR spectroscopy. It works by recording the relationship between nitrogen and potassium atoms in the slurry, and can eventually be an inexpensive and accurate instrument for measuring ammonia emissions.

The researchers also have a number of other ideas in the pipeline, and the project's total number of monitoring and cleaning technologies will provide the farming industry with better opportunities to adapt to current environmental legislation.

"If farmers can carry out accurate monitoring of ammonia emissions from animal housing, they can also make their operations more efficient. And if they can clear the air of ammonia at the same time and collect it for fertilising purposes, they'll also be able to significantly reduce the environmental impact," says Associate Professor Feilberg.

Photo: Rasmus Nyholm Jørgensen

Researchers can already take high-resolution images of weeds, even when driving at 50 km/h in the field. The aim is to make the entire spraying process as autonomous as possible.

How deep learning can help farmers get rid of weeds

By using a number of digital technologies, it is possible today to produce an overview of the type of weeds farmers are struggling with, and show exactly where they are located in the fields. This can mean a significant reduction in the amount of herbicides used.

To combat weeds, farmers have been spraying their fields with herbicides for decades. Until now, however, they have used a standard mixture of sprays which are spread over the entire field. This is not particularly smart from either a financial point of view or an environmental or biological perspective because herbicides are expensive, can have implications for the water quality in streams and groundwater, and lead to resistance in the weeds. Not to mention that a standard mixture of herbicides may have a good effect on some species of weeds, but a less effective impact on others. And with a new EU directive stating that farmers should not spray before first inspecting the fields and determining the type of weeds in accordance with the principles of integrated plant protection, there is an extremely great need for a smart solution.

But is it at all possible to make the spraying process smart? This is what Aarhus University researchers have been studying since 2012, and they have actually achieved success via a combination of cameras, Big Data and machine learning, in interaction with an existing decision support system (PlanteVærn Online).

"Currently, farmers don't know what sort of weeds they have in their fields, and this knowledge is necessary. Not only regarding the use of the right herbicide, but also in relation to the regulations stipulated by the EU. But the farmers don't have time to go round the fields and find out which weeds are growing there. This is where we can help with our technique which can outline the problem and thereby pro-

project facts

TITLE
RoboWeedMaPS - Automated Weed detection, Mapping and Variable Precision Control of Weeds

SCHEDULE
2017-2020

FINANCIAL FRAMEWORK
DKK 34.6 million
Innovation Fund Denmark

PROJECT PARTNERS
AgroIntelli ApS
IPM Consult ApS
Datalogisk A/S
Danfoil A/S
I•GIS ApS

CONTACT
Senior Researcher
Rasmus Nyholm Jørgensen
rnj@eng.au.dk

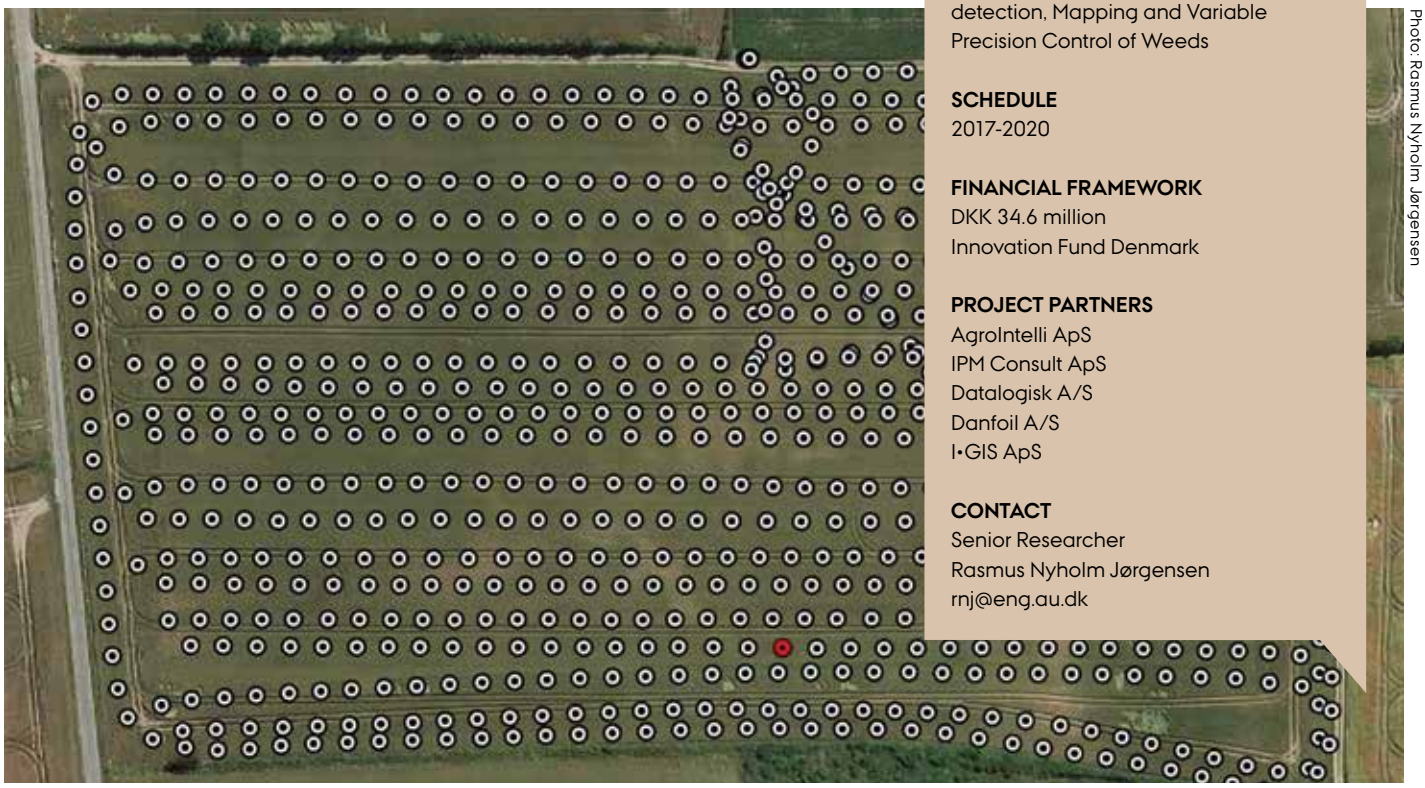


Photo: Rasmus Nyholm Jørgensen

This image shows a survey of weeds in a field. Each individual dot represents an image. Put together, this provides a very precise indication of the type of weeds causing havoc at particular parts of the field.

vide the basis for saving a considerable amount of spray," says Senior Researcher Rasmus Nyholm Jørgensen.

Purple or green weeds
The technique involves attaching a row of high-resolution cameras to a wide bar on a tractor or directly on the farmer's tools in the field. Alternativly a consumer drone may also be used. When the farmer drives through the vehicle tracks in the field, each camera takes lots of photos. Via the image positions, it is possible to piece the images together and create a comprehensive map of the crops and weeds in the field.

The images are automatically uploaded in the cloud, where they are analysed by several specialised algorithms for the composition of the weeds compared with the competitive ability of the crops. This is where Big Data come into the picture because the whole system relies on an enormous 'weed data base', where the researchers use deep learning to teach the computer to recognise different types of weeds.

Although it might sound simple, it is actually quite difficult to automate the process, particularly because weeds in the fields hardly ever resemble those in the weed botanical books.

"The problem with recognising weeds is that they change shape. It only takes a small beetle to eat a leaf and the plant doesn't look like the one in the image at all. Or the stems can be so thin that – in the image – it looks as though the leaves aren't connected. And if it's cold in spring, some weeds turn completely purple even though they're normally green," says Senior Researcher Jørgensen, pointing out that the computer therefore has to chew through a considerable amount of data in order to distinguish each individual type of weed from the other.

He compares this with driving a car. "Using pedals and gears doesn't come automatically and sub-conscious, so until you've been out driving a lot, you feel uncertain. But if you've tried out a car simulator beforehand, these basic things become automatic and sub-conscious. Just like pilots. And that's what we're doing in our project. We train the neural network with artificial images in the simulator prior to releasing it into the real world," he says.

Making life easier
The project has now reached the stage where the cameras can take high-resolution images with an accuracy of 4 pixels per millimetre, even when driving at 50 km/h in the field, and where the computer has satisfactorily learned to recognise 27 types of weeds from a data base with thousands of images. The computer is trained with far more species of weeds, but the number of training images is still too small to achieve strong recognition.

The aim is to make everyday life easier for farmers, so that the computer itself finds where the weeds are located, what type they are, and which type of herbicide should be used at precisely that spot in the field. The computer will thus control the dosage when farmers are spraying their fields, and even regulate different types of herbicides and dosages depending on the type of weed – an important part of the future smart farming.

Huge project to demonstrate how the Internet will fundamentally change farming

The EU Framework Programme for Research and Innovation is investing a two-figure million amount in a major demonstration project that will show how farming can make use of smart IT solutions such as Big Data, Artificial Intelligence and the Internet of Things (IoT).

Although it may not always occur to you when you see farmers painstakingly trundling their tractors up and down the fields casting long shadows in the red glow of sunrise, many technologies have been developed in recent decades that aim to streamline and automate agricultural production once they have been fully implemented.

These include optimised route planning for farming machines, automatic steering and web-based monitoring of soil humidity.

However, even though the agri-food sector has generally been willing to adopt technologies such as Big Data, Artificial Intelligence and IoT, their use is currently still fragmented and the technologies are mainly used by early adopters.

This inadequate use of new technologies has an impact on both productivity and sustainability. The challenge is to nurture a development where farmers embrace these technologies – which are precisely tailored to farming.

A major new EU project will speed up this development.

"This is a paradigm shift. It's a new way of going about farming, which will be transformed into a web of connected objects that can be identified, measured, controlled and remotely operated. There are so many advanced technologies that aren't really being used. This project will show the world how to go about using them," says Senior Researcher Claus Grøn Sørensen.

What is in it for me

The project is called the Internet of Food & Farm 2020, and it aims to demonstrate via 19 different case studies how IoT can drastically improve productivity and sustainability in European farming as we know it today.

The case studies will present concepts such as data exchange between machines, smart crop management and intelligent logistics.

The project will also demonstrate business models for the relevant technologies.

Both machines and farms have become significantly larger (and continue to grow) as a result of the ongoing structural development in the industry. Labour costs have gone up, and product prices are being squeezed all the time, which means there is an ever-increasing need for efficient production management. If farmers are to be sure of making a profit, this includes ensuring farm machines that work seamlessly with each other.

It is possible that new technologies have therefore been welcome but, in most cases, this has also involved a considerable investment, making it difficult to spot the benefits.

"A typical farmer will ask what he's going to get out of it. And for many years, this has been hard for researchers to actually demonstrate. The problem has often been that technologically advanced systems have been developed, but that they've simply been too complicated. If there's too much user interaction – i.e. if the farmers themselves have to spend a lot of time keeping track of the systems – it just doesn't work. They don't have time for that. But if we can demonstrate that the systems are easy to use, and that there's an advantage – a sensible business model – the farmers will take it to heart," says Senior Researcher Sørensen.

Photo: Anders Trærup

Farmers will hardly need to keep their hands on the steering wheel when they are ploughing the fields in the future. Senior Researcher Claus Grøn Sørensen is shown here behind the wheel. He is working on fully automated and autonomous farming in the future.

A glorious story of autonomy

In other words, there has been a lack of completeness. What has been lacking is the impression of how machines that work together smoothly can create coherence, quality and profit in production. However, this is now possible with the breakthroughs provided by information technology.

There are many countries in which farming has had a glorious history for millennia as the most predominant industry and as the guarantor of economic progress. This is no longer the case, but farming is still very important for the food industry and export.

And it will no doubt continue this way. However, farmers of the future are unlikely to sit behind the steering wheel of the tractor when it trundles up and down the fields. It will drive itself as part of fully automated and autonomous farming when IoT seriously catches on in the industry.

project facts

TITLE
Internet of Food & Farm 2020

SCHEDULE
2017–2020

FINANCIAL FRAMEWORK
EUR 35 million
EU Framework Programme for Research and Innovation

PROJECT PARTNERS
There are 73 partners in the Internet of Food & Farm 2020 project.

CONTACT
Senior Researcher
Claus Aage Grøn Sørensen
claus.soerensen@eng.au.dk

Navitas Campus, Aarhus

Photo: Jesper Rais

PUBLICATIONS

AU Engineering Peer Reviewed Publications 2016

JOURNAL ARTICLES

3D impurity inspection of cylindrical transparent containers. / Kragh, Mikkel Fly; Bjerge, Kim; Ahrendt, Peter. In: Measurement Science and Technology, Vol. 28, No. 1, 2016.

A Comparison between Temperature-Controlled Laminar Airflow Device and a Room Air-Cleaner in Reducing Exposure to Particles While Asleep. / Spilak, Michal P; Sigsgaard, Torben; Takai, Hisamitsu; Zhang, Guoqiang. In: PLoS One, Vol. 11, No. 11, 2016.

A Low-Power Fast Tag Comparator by Modifying Charging Scheme of Wide Fan-in Dynamic OR gates. / Nasserian, Mahshid; Kafi-Kangi, Mohammad; Maymandi Nejad, Mohammad; Moradi, Farshad. In: Integration, Vol. 52, 2016.

A near fatal anaphylaxis requiring 32 min of CPR after bee sting challenge in mastocytosis patient under ongoing specific immunotherapy: due to molecular mismatch of honey bee allergens (Api m10) between VIT extract and crude honey bee venom? / Micaletto, Sara; Ruetzler ,Kurt, Ruetzler; Ollert, Markus; Blank, Simon; Spillner, Edzard; Hoetzenecker, Wolfram; Bruesch, Martin; Schmid-Grendelmeier, Peter. In: Journal of Allergy and Clinical Immunology, 2016.

A Novel Method for Optical High Spatiotemporal Strain Analysis for Transcatheter Aortic Valves In Vitro. / Heide-Jørgensen, Simon; Kumaran Krishna, Sellaswasmy; Taborsky, Jonas; Bechsgaard, Tommy Kragh; Zegdi, Rachid; Johansen, Peter. In: Journal of Biomechanical Engineering, Vol. 138, No. 3 .2016.

A Novel Nondestructive Bit-Line Discharging Scheme for Deep Submicrometer STT-RAMs. / Zeinali, Behzad; Madsen, Jens Kargaard; Raghavan, Praveen; Moradi, Farshad. In: IEEE Transactions on Emerging Topics in Computing, 2016.

A numerical study on forced convective heat transfer of a chicken (model) in horizontal airflow. / Li, Hao; Rong, Li; Zong, Chao; Zhang, Guoqiang. In: Biosystems Engineering, Vol. 150, 2016.

A Palladium-Catalyzed Double Carbonylation Approach to Isatins from 2-Iodoanilines. / Laursen, Simon; Jensen, Mikkel T.; Lindhardt, Anders T.; Jacobsen, Mikkel F.; Skrydstrup, Troels. In: European Journal of Organic Chemistry, Vol. 2016, No. 10, 2016.

A secure dynamic collaboration environment in a cloud context. / Piechottaa, Chris ; Olsen, Martin Grooss; Jensen, Adam Enø; Colemann , Joey W.; Larsen, Peter Gorm. In: Future Generation Computer Systems, Vol. 55, 2016.

A Smart Combination of Power Productive Gas Expansion Station and Solar Assisted Absorption Chiller for Integrating Heat, Cooling and Electricity Sectors. / Arabkoohsar, Ahmad; Andresen, Gorm. In: Energy Conversion and Management, 2016.

A system for monitoring real-time body parameters of sows using a lightweight and flexible wireless sensor platform. / Kjeldsen, Martin ; Gregersen, Torben; Wagner, Stefan Rahr; Bøgh, Christian G V; Nielsen, Carsten. In: Journal of Agricultural Informatics, Vol. 7, No. 1, 2016.

A toolbox to evaluate non-residential lighting and daylighting retrofit in practice. / Gentile, Niko; Dubois, Marie-Claude; Osterhaus, Werner; Stoffer, Sophie; Amorim, Cláudia Naves David; Geisler-Moroder, David; Jakobiak, Roman. In: Energy and Buildings, Vol. 123, 2016.

Adoption of BIM Systems in the AEC Industry. / Kirkegaard, Poul Henning; Zandieh, Mahdi; Mahmuodzadeh Kani, Iradj; Hessari, Pedram. In: PONTE, 2016.

Ambient Assisted Living Care Technology Assessment Method. / Beevi, Femina Hassan Aysha; Wagner, Stefan Rahr; Hallerstede, Stefan; Pedersen, Christian Fischer. In: International Journal of Technology Assessment in Health Care, 2016.

Ammonia abatement by slurry acidification: A pilot-scale study of three finishing pig production periods. / Petersen, Søren O.; Hutchings, Nicholas John; Hafner, Sasha; Sommer, Sven G.; Hjorth, Maibritt; Jonassen, Kristoffer. In: Agriculture, Ecosystems & Environment, Vol. 216, 2016.

An Open Platform for Seamless Sensor Support in Healthcare for the Internet of Things. / Miranda, Jorge; Cabral, Jorge; Wagner, Stefan Rahr; Pedersen, Christian Fischer; Ravelo, Blaise; Memon, Mukhtiar; Mathiesen, Morten. In: Sensors, Vol. 16, No. 12, 2016.

Anaerobic digestion of sulfate-acidified cattle slurry: One-stage vs. two-stage. / Hernandez, Veronica Moset; Ottosen, Lars Ditlev Mørck; de Almeida Neves Xavier, Cristiane; Møller, Henrik Bjarne. In: Journal of Environmental Management, Vol. 173, 2016.

Analysis and model delineation of marine microalgae growth and lipid accumulation in flat-plate photobioreactor. / Yong-Jin, He; Chen, Langjun ; Zhou, Youcai; Chen, Han; Zhou, Xiuli; Cai, Fan; Huang, Jian; Wang, Mingzi; Chen, Bilian; Guo, Zheng. In: Biochemical Engineering Journal, Vol. 111, 2016.

Antioxidant Efficacies of Rutin Esters in Bulk Oil and Oil-in-Water Emulsion. / Lue, Bena-Marie; Sørensen, Ann-Dorit Moltke; Jacobsen, Charlotte; Guo, Zheng; Xu, Xuebing. In: European Journal of Lipid Science and Technology, 2016.

Appliance Scheduling Optimization for Demand Response. / Ghasem Azar, Armin; Jacobsen, Rune Hylsberg. In: International Journal On Advances in Intelligent Systems, Vol. 9, No. 1 & 2, 2016.

Assessing the actions of the farm managers to execute field operations at opportune times. / Edwards, Gareth Thomas Charles; Dybro, Niels; Munkholm, Lars Juhl; Sørensen, Claus Aage Grøn. In: Biosystems Engineering, No. 144, 2016.

Assessing sustainability at farm-level: Lessons learned from a comparison of tools in practice. / de Olde, Evelien; Oudshoorn, Frank Willem; Sørensen, Claus Aage Grøn; Bokkers, Eddie A.M.; de Boer, Imke J.M. In: Ecological Indicators, Vol. 66, 2016.

Assessing the Sustainability Performance of Organic Farms in Denmark. / de Olde, Evelien; Oudshoorn, Frank Willem; Bokkers, Eddie A.M.; Stubsgaard, Anke ; Sørensen, Claus Aage Grøn; de Boer, Imke J.M. In: Sustainability, Vol. 8, No. 9, 2016.

Automated coating procedures to produce poly(ethylene glycol) brushes in fused-silica capillaries. / Poulsen, Nicklas N.; Østergaard, Jesper; Petersen, Nickolaj J.; Daasbjerg, Kim; Iruthayaraj, Joseph; Dedinaite, Andra; Makuska, Ricardas; Jensen, Henrik. In: Journal of Separation Science, 2016.

Automatic behaviour analysis system for honeybees using computer vision. / Tu, Gang Jun; Hansen, Mikkel Kragh; Kryger, Per; Ahrendt, Peter. In: Computers and Electronics in Agriculture, Vol. 122, 2016.

Automatic Sleep Stage Classification using Ear-EEG. / Stockholm, Andreas; Mikkelsen, Kaare; Kidmose, Preben. In: IEEE Engineering in Medicine and Biology Society, Conference Proceedings, 2016.

Autonomous Relaying Scheme with Minimum User Power Consumption in Cooperative Multicast Communications. / Zhao, Guodong ; Shi, Wuyu ; Chen, Zhi ; Zhang, Qi. In: IEEE Transactions on Wireless Communications, Vol. 15, No. 4, 2016.

Backup flexibility classes in emerging large-scale renewable electricity systems. / Schlachtberger, D. P.; Becker, S.; Schramm, S.; Greiner, Martin. In: Energy Conversion and Management, Vol. 125, 2016.

Biosynthesis of Phosphatidyl Vitamin B6 by Phospholipase D Catalyzed Transphosphatidylation. / Guo, Zheng; Xu, Xuebing. In: Austin Food Sciences, Vol. 1, No. 1, 2016.

Carbon dioxide and methane emissions from the scale model of open dairy lots. / Ding, Luyu; Cao, Wei; Shi, Zhengxiang; Li, Baoming; Wang, Chaoyuan; Zhang, Guoqiang; Kristensen, Simon. In: Air & Waste Management Association Journal, Vol. 66, No. 7, 2016.

Case comparison of sleep features from ear-EEG and scalp-EEG. / Zibrandtsen, I.; Kidmose, Preben; Otto, M.; Ibsen, J.; Kjaer, T.W. In: Sleep Science, Vol. 9, No. 2, 2016.

Changing Feeding Regimes To Demonstrate Flexible Biogas Production: Effects on Process Performance, Microbial Community Structure, and Methanogenesis Pathways. / Mulat, Daniel Girma; Jacobi, H. Fabian; Feilberg, Anders; Adamsen, Anders Peter S.; Richnow, Hans-Hermann ; Nikolausz, Marcell. In: Applied and Environmental Microbiology, Vol. 82, No. 2, 2016.

Choosing the appropriate sensitivity analysis method for building energy model-based investigations. / Kristensen, Martin Heine; Petersen, Steffen. In: Energy and Buildings, Vol. 130, 2016.

Closed-form modelling and design analysis of V- and Z-shaped electrothermal microactuators. / Zhang, Zhuo; Zhang, Weize; Wu, Qiyang ; Yu, Yueqing; Liu, Xinyu; Zhang, Xuping. In: Journal of Micromechanics and Microengineering, Vol. 27, No. 1, 2016.

Collaborative Model-based Systems Engineering for Cyber-Physical Systems, with a Building Automation Case Study. / Fitzgerald, John; Gamble, Carl; Payne, Richard; Larsen, Peter Gorm; Basagiannis, Stylianos; Mady, Ali El-Din. In: INCOSE International Symposium, Vol. 26, No. 1 .2016.

Comparing maximum autonomic activity of psychogenic non-epileptic seizures and epileptic seizures using heart rate variability. / Jeppesen, Jesper; Beniczky, Sándor; Johansen, Peter; Sidenius, Per Christian; Fuglsang-Frederiksen, Anders. In: Seizure - European Journal of Epilepsy, Vol. 37 .2016.

Composition, potential emissions and agricultural value of pig slurry from Spanish commercial farms. / Antezana, W.; de Blas, Carlos; García-Rebollar, Paloma; Rodríguez, Carlos; Beccaccia, Amanda; Ferrer, P; Cerisuelo, A.; Hernandez, Veronica Moset; Estelles, F; Cambra-Lopez, M; Calvet, S. In: Nutrient Cycling in Agroecosystems, Vol. 104, No. 2, 2016.

Concurrent extraction and transformation of bioactive phenolic compounds from rapeseed meal using pressurized solvent extraction system. / Li, Jingbo; Guo, Zheng. In: Industrial Crops and Products, Vol. 94 .2016.

Cooperative redox activation for carbon dioxide conversion. / Lian, Zhong; Nielsen, Dennis U.; Lindhardt, Anders T.; Daasbjerg, Kim; Skrydstrup, Troels. In: Nature Communications, Vol. 7, 2016.

DeepAnomaly : Combining Background Subtraction and Deep Learning for Detecting Obstacles and Anomalies in an Agricultural Field. / Christiansen, Peter; N. Nielsen, Lars; A. Steen, Kim ; Nyholm Jørgensen, Rasmus; Karstoft, Henrik. In: Sensors, Vol. 16, No. 11, 2016.

Demand Response Potential of Model Predictive Control of Space Heating based on Price and Carbon Dioxide Intensity Signals. / Knudsen, Michael Dahl; Petersen, Steffen. In: Energy and Buildings, Vol. 125, 2016.

Demand Response Potential of Ventilation Systems in Residential Buildings. / Rotger Griful, Sergi; Jacobsen, Rune Hylsberg; Nguyen, Dat ; Sørensen, Gorm. In: Energy and Buildings, Vol. 121, 2016.

Design and Analysis of the Novel Concept of High Temperature Heat and Power Storage. / Arabkoohsar, Ahmad; Andresen, Gorm. In: Energy, 2016.

Development of a Palladium-Catalyzed Carbonylative Coupling Strategy to 1,4-Diketones. / Yin, Hongfei; Nielsen, Dennis Ulsøe; Kiilerich Johansen, Mette; Lindhardt, Anders Thyboe; Skrydstrup, Troels. In: ACS Catalysis, Vol. 6, No. 5, 2016.

Development of kinetic model for biodiesel production using liquid lipase as a biocatalyst, esterification step. / Yusoff, Mohd Firdaus Bin Mohammad; Guo, Zheng; Fedosov, Sergey. In: Biochemical Engineering Journal, Vol. 105, 2016.

Dicotyledon Weed Quantification Algorithm for Selective Herbicide Application in Maize Crops. / Laursen, Morten Stigaard; Nyholm Jørgensen, Rasmus; Midtiby, Henrik Skov; Jensen, Kjeld; Christiansen, Martin Peter; Gislesson, Thomas Mosgaard; Mortensen, Anders Krogh; Jensen, Peter Kryger. In: Sensors, Vol. 16, No. 11, 2016.

Direct Solar Charging of an Organic–Inorganic, Stable, and Aqueous Alkaline Redox Flow Battery with a Hematite Photoanode. / Wedege, Kristina; Azevendo, Joao; Khataee, Amirreza; Bentien, Anders; Mendes, Adélio. In: Angewandte Chemie (International Edition), Vol. 55, No. 25, 2016.

Doubling the spectrum of time-domain induced polarization by harmonic de-noising, drift correction, spike removal, tapered gating and data uncertainty estimation. / Olsson, Per-Ivar; Fiandaca, Gianluca; Larsen, Jakob Juul; Dahlin, Torleif; Auken, Esben. In: Geophysical Journal International, Vol. 207, No. 2, 2016.

Dynamic Comparative Analysis of Erickson Cycle Based and Rankin Cycle Based High Temperature Heat and Power Storage Systems. / Arabkoohsar, Ahmad; Andresen, Gorm. In: Applied Energy, 2016.

Dynamic Energy, Exergy and Economic Analysis of the High Temperature Heat and Power Storage System. / Arabkoohsar, Ahmad; Andresen, Gorm. In: Energy, 2016.

Dynamic Modelling and Analysis of V- and Z-shaped Electrothermal Microactuators. / Zhang, Zhou; Yu, Yueqing; Liu, Xinyu; Zhang, Xuping. In: Microsystem Technologies, 2016.

Economic modelling of controlled traffic for vegetable production. / McPhee, J E; Maynard, J. R.; Aird, P.L.; Pedersen, Hans Henrik; Tullberg, J. N. In: AFBM Journal, Vol. 13, 2016.

Economizing CHP System Application in Power Productive Natural Gas Stations. / Arabkoohsar, Ahmad; Farzaneh-Gord, M. In: Energy, 2016.

Effect of acidification on solid–liquid separation of pig slurry. / Cocolo, Giorgia; Hjorth, Maibritt; Zarebska, Agata; Provolo, Giorgio. In: Biosystems Engineering, Vol. 143, 2016.

Effect of pulsation rest phase duration on teat end congestion. / Upton, John; Penry, J.F.; Rasmussen, Morten Dam; Thompson, P.D.; Reinemann, D.J. In: Journal of Dairy Science, Vol. 99, No. 5, 2016.

Efficacy and toxicity management of CAR-T cell immunotherapy: a matter of responsiveness control or tumor-specificity? / Alonso-Camino, Vanesa; Harwood, Seandean Lykke; Alvarez-Méndez, Ana M; Álvarez-Vallina, Luis. In: Biochemical Society Transactions, Vol. 44, No. 2, 2016.

Energy and Exergy Analysis of Fluidized Bed Citric Acid Dryers. / Deymi Dashtebayaz, M.; Arabkoohsar, Ahmad; Darabian, F. In: International Journal of Exergy, 2016.

Enhancing non-technical skills by a multidisciplinary engineering summer school. / Larsen, Peter Gorm; Kristiansen, Erik Lasse; Bennedsen, Jens; Bjerge, Kim. In: European Journal of Engineering Education, 2016.

Establishing an image-based ground truth for validation of sensor data-based room occupancy detection. / Petersen, Steffen; Pedersen, Theis; Ubbe Nielsen, Kasper; Knudsen, Michael Dahl. In: Energy and Buildings, Vol. 130, 2016.

Evaluation of defects in adhesive joint by double cantilever beam experiment. / Budzik, Michal Kazimierz; Jensen, Henrik Myhre. In: Key Engineering Materials, Vol. 665, 2016.

Evaluation of POEGMA Coated Stainless Steel Surfaces for Microbial and In-organic Fouling in Heat Exchanger Applications. / Subbiahdoss, Guruprakash; Holm, Allan Hjarbæk; Friis, Jakob Ege; Salmi, Zakaria; Blichfeld, Anders Bank; Daasbjerg, Kim; Iruthayaraj, Joseph; Meyer, Rikke Louise. In: Biofouling, 2016.

Flexibility mechanisms and pathways to a highly renewable US electricity future. / Frew, Bethany A.; Becker, Sarah; Dvorak, Michael J.; Andresen, Gorm; Jacobson, Mark Z. In: Energy, Vol. 101, 2016.

Fourier and granulometry methods on 3D images of soil surfaces for evaluating soil aggregate size distribution. / Jensen, T.; Green, O.; Munkholm, Lars Juhl; Karstoft, Henrik. In: American Society of Agricultural and Biological Engineers. Transactions, Vol. 32, No. 5, 2016.

Functional modeling for green biomass supply chains. / Pavlou, D; Orfanou, A; Busato, P; Berruto, R; Sørensen, Claus Aage Grøn; Bochtis, Dionysis. In: Computers and Electronics in Agriculture, Vol. 122, 2016.

Generalized Flow Tracing for the Analysis of Networked Renewable Electricity Systems. / Schäfer, Mirko; Becker, Sarah; Schramm, Stefan; Greiner, Martin. In: arXiv. 2016.

Graphene-Based STT-RAM Cell with Improved Switching for Scaled Technology Nodes. / Varghani, Ali; Peiravi, Ali; Moradi, Farshad. In: IEEE Transactions on Magnetics, Vol. 52, No. 1, 2016.

Green Lift : Exploring the Demand Response Potential of Elevators in Buildings. / Rotger Griful, Sergi; Jacobsen, Rune Hylsberg; Brewer, Robert S.; Rasmussen, Mia Kruse. In: Energies, 2016.

Greenhouse gas emissions from dairy open lot and manure stockpile in northern China: A case study. / Ding, Luyu; Lu, Qikun; Xie, Lina; Liu, Jie; Wei, Cao; Shi, Zhengxiang ; Li, Baoming; Wang, Chaoyuan ; Zhang, Guoqiang; Ren, Shixi. In: Journal of the Air and Waste Management Association, Vol. 66, No. 3, 2016.

High Throughput Identification and Quantification of Phospholipids in Complex Mixtures. / Balsgart, Nicholas Mcleod; Mulbjerg, Mette; Guo, Zheng; Bertelsen, Kresten; Vosegaard, Thomas. In: Analytical Chemistry, Vol. 88, No. 4, 2016.

Highly integrated optical phased arrays: photonic integrated circuits for optical beam shaping and beam steering. / Heck, Martijn. In: Nanophotonics, Vol. 6, No. 1, 2016.

Human IgE is efficiently produced in glycosylated and biologically active form in lepidopteran cells. / Bantleon, Frank I; Wolf, Sara; Seismann, Henning; Dam, Svend Secher; Lorentzen, Andrea; Miehe, Michaela; Jabs, Frederic; Thilo Jakob; Plum, Melanie; Spillner, Edzard. In: Molecular Immunology, Vol. 72, 2016.

Human serum substitution by artificial sera of scalable allergen reactivity based on polyclonal antibodies and chimeras of human Fc RI and IgE domains. / Offermann, Nadine; Plum, Melanie; Hübner, Uschi; Fooke, Margrit; Spillner, Edzard. In: Allergy, Vol. 71, No. 12, 2016.

Hydrophilic Polymer Brush Layers on Stainless Steel Using Multilayered ATRP Initiator Layer. / Friis, Jakob Ege; Brøns, Kaare; Salmi, Zakaria; Shimizu, Kyoko; Subbiahdoss, Guruprakash; Holm, Allan Hjarbæk ; Santos, Olga; Pedersen, Steen Uttrup; Meyer, Rikke Louise; Daasbjerg, Kim; Iruthayaraj, Joseph. In: ACS applied materials & interfaces, Vol. 8, No. 44, 2016.

Identification and quantification of phenolic compounds in rapeseed originated lecithin and antioxidant activity evaluation. / Li, Jingbo; Guo, Zheng. In: Lebensmittel – Wissenschaft und Technologie - Food Science and Technology, Vol. 73, 2016.

Identification of syntrophic acetate-oxidizing bacteria in anaerobic digesters by combined protein-based stable isotope probing and metagenomics. / Mosbæk, Freya; Kjeldal, Henrik; Mulat, Daniel Girma; Albertsen, Mads; Ward, Alastair James; Feilberg, Anders; Nielsen, Jeppe. In: The ISME Journal, Vol 10, No. 10, 2016.

Immune regulation by pericytes: modulating innate and adaptive immunity. / Navarro, Rocio; Compte, Marta; Álvarez-Vallina, Luis; Sanz, Laura. In: Frontiers in Immunology, Vol. 7, 2016.

In-ear EEG from Viscoelastic Generic Earpieces: Robust and Unobtrusive24/7 Monitoring. / Goverdovsky, Valentin; Looney, David; Kidmose, Preben; Mandic, Danilo P. In: IEEE Sensors Journal, Vol. 16, No. 1, 2016.

Influence of sidewall openings on air change rate and airflow conditions inside and outside low-rise naturally ventilated buildings. / Shen, Xiong; Su, Ruoyu; K. Ntinas, Georgios; Zhang, Guoqiang. In: Energy and Buildings, Vol. 130, 2016.

Intramolecular trimerization, a novel strategy for making multispecific antibodies with controlled orientation of the antigen binding domains. / Álvarez-Cienfuegos, Ana; Alanes, Natalia Nuñez del Prado; Compte, Marta; Cuesta, Àngel M; Blanco-Toribio, Ana; Harwood, Seandean Lykke; Villate, Maider; Merino, Nekane; Bonet, Jaume; Navarro, Rocio; Muñoz-Briones, Clara; Sørensen, Karen Marie Juul; Mølgaard, Kasper; Oliva, Baldomero; Blanco, Francisco J; Álvarez-Vallina, Luis. In: Scientific Reports, Vol. 6, 2016.

Investigating Concurrency in the Co-Simulation Orchestration Engine for INTO-CPS. / Thule, Casper; Larsen, Peter Gorm. In: Proceedings of the Institute for System Programming, Vol. 28, No. 2, 2016.

Key Mechanisms for Employee-Driven Innovation in Governmental Client Organisations. / Sørensen, Henrik; Wandahl, Søren; Ussing, Lene Faber; Christensen, Randi Muff. In: International Journal of Entrepreneurship and Innovation Management, 2016.

Kinetic model of biodiesel production catalyzed by free liquid lipase from Thermomyces lanuginosus. / Yusoff Firdaus, Mohamad; Brask, Jesper; Munk Nielsen, Per; Guo, Zheng; Fedosov, Sergey. In: Journal of Molecular Catalysis B: Enzymatic, Vol. 133, 2016.

Level and distribution of odorous compounds in pig exhaust air from combined room and pit ventilation. / Huffel, Katrijn Van; Hansen, Michael Jørgen; Feilberg, Anders; Liu, Dezhao; Langenhove, Herman Van L. In: Agriculture, Ecosystems & Environment, Vol. 218, 2016.

Limited memory influence diagrams for structural damage detection decision-making. / Hovgaard, Mads Knude; Brincker, Rune. In: Journal of Civil Structural Health Monitoring, Vol. 6, No. 2, 2016.

Low-Energy Write Operation for 1T-1MTJ STT-RAM Bitcells With Negative Bitline Technique. / Farkhani, Hooman; Peiravi, Ali; Moradi, Farshad. In: IEEE Transactions on Very Large Scale Integration (VLSI) Systems, Vol. 24, No. 4, 2016.

Low-leakage sub-threshold 9T-SRAM cell in 14-nm FinFET technology. / Zeinali, Behzad; Madsen, Jens Kargaard; Raghavan, Praveen; Moradi, Farshad. In: International Journal of Circuit Theory and Applications, 2016.

Mechanisms of natural ventilation in livestock buildings : Perspectives on past achievements and future challenges. / Rong, Li; Bjerg, Bjarne; Batzanas, Thomas; Zhang, Guoqiang. In: Biosystems Engineering, Vol. 151, 2016.

Micro-scale H2-CO2 dynamics in a hydrogenotrophic methanogenic membrane reactor. / Garcia-Robledo, Emilio; Ottosen, Lars Ditlev Mørck; Voigt, Niels Vinther; Kofoed, Michael; Revsbech, Niels Peter. In: Frontiers in Microbiology, Vol. 7, 2016.

Mining catalytic promiscuity from Thermophilic archaea: an acyl-peptide releasing enzyme from Sulfolobus tokodaii (ST0779) for nitroaldol reactions. / Yu, Xiaoxiao; Pérez, Bianca; Zhang, Zhefei; Gao, Renjun; Guo, Zheng. In: Green Chemistry, 2016.

Model-based subtraction of spikes from surface nuclear magnetic resonance data. / Larsen, Jakob Juul. In: Geophysics, Vol. 81, No. 4, 2016.

Modelling the readiness of soil for different methods of tillage. / Edwards, Gareth; White, D W R; Munkholm, Lars Juhl; Grøn Sørensen, Claus; Lamandé, Mathieu. In: Soil & Tillage Research, Vol. 155, 2016.

Modulation of N-bonding configurations and their influence on the electrical properties of nitrogen-doped graphene. / Wang, Zegao; Chen, Yuanfu; Li, Pingjian; Zhou, Jinhao; He, Jiarui; Zhang, Wanli; Guo, Zheng; Li, Yanrong; Dong, Mingdong. In: RSC Advances, Vol. 6, No. 95, 2016.

Morphology-preserving transformation of minerals mediated by a temperature-responsive polymer membrane : Calcite to hydroxyapatite. / Jensen, Anders Christian Solberg; Brif, A; Pokroy, B; Hinge, Mogens; Birkedal, H. In: CrystEngComm, Vol. 18, No. 13, 2016.

Multivariate prediction of odor from pig production based on in-situ measurement of odorants. / Hansen, Michael Jørgen; Jonassen, Kristoffer E N; Løkke, Mette Marie; Adamsen, Anders Peter S.; Feilberg, Anders. In: Atmospheric Environment, Vol. 135, 2016.

Near Infrared Spectroscopy for determination of biochemical methane potential: state of the art. / Ward, Alastair James. In: Chemical Engineering and Technology, Vol. 39, No. 4, 2016.

Nyt elektrofilter kan fjerne 98-99 procent af støvet fra halmfyring. / Kristensen, Erik Fløjgaard. In: Forskning i Bioenergi, Brint & Brændselsceller, Vol. 13, No. 58, 2016.

Operational Modal Analysis and Wavelet Transformation for Damage Identification in Wind Turbine Blades. / Dalgaard Ulriksen, Martin; Tcherniak, Dmitri; Kirkegaard, Poul Henning; Damkilde, Lars. In: Structural Health Monitoring, Vol. 15, No. 4, 2016.

Organic Redox Species in Aqueous Flow Batteries: Redox Potentials, Chemical Stability and Solubility. / Wedege, Kristina; Dražević, Emil; Konya, Denes; Bentien, Anders. In: Scientific Reports, Vol. 6, 2016.

Pain detection from facial image using unsupervised feature learning approach. / Kharghanian, Reza; Peiravi, Ali; Moradi, Farshad. In: IEEE Engineering in Medicine and Biology Society, Conference Proceedings, 2016.

Palladium-Catalyzed Carbonylative α-Arylation of tert-Butyl Cyanoacetate with (Hetero)aryl Bromides. / Jensen, Mikkel Troldtoft; Juhl, Martin; Nielsen, Dennis Ulsøe; Jacobsen, Mikkel Fog; Lindhardt, Anders Thyboe; Skrydstrup, Troels. In: The Journal of Organic Chemistry, Vol. 81, No. 4, 2016.

Performance evaluation of full-scale tuned liquid dampers (TLDs) for vibration control of large wind turbines using real-time hybrid testing. / Zhang, Zili; Staino, Andrea; Basu, Biswajit; Nielsen, Søren R. K. In: Engineering Structures, Vol. 126, 2016.

Plant species classification using deep convolutional neural network. / Dyrmann, Mads; Karstoft, Henrik; Midtiby, Henrik Skov. In: Biosystems Engineering, Vol. 151, 2016.

Plasma Functionalized Multiwalled Carbon Nanotubes for Immobilization of Candida antarctica Lipase B: Production of Biodiesel from Methanolysis of Rapeseed Oil. / Rastian, Zahra; Khodadadi, Abbas Ali; Guo, Zheng; Vahabzadeh, Farzaneh; Mortazavi, Yadollah. In: Applied Biochemistry and Biotechnology, Vol. 178, No. 5, 2016.

Plasmonically enhanced upconversion of 1500 nm light via trivalent Er in a TiO2 matrix. / Lakhotiya, Harish; Nazir, Adnan; Madsen, Søren Peder; Christiansen, Jeppe; Eriksen, Emil; Vester-Petersen, Joakim; Johannsen, Sabrina Rostgaard; Jeppesen, Bjarke Rolighed; Balling, Peter; Larsen, Arne Nylandsted; Julsgaard, Brian. In: Applied Physics Letters, Vol. 109, No. 26, 2016.

Predominant Api m 10 sensitisation as risk factor for treatment failure in honey bee venom immunotherapy. / Frick, Marcel; Fischer, Jörg; Helbing, Arthur; Ruëff, Franziska; Wieczorek, Dorothea; Ollert, Markus; Pfützner, Wolfgang; Müller, Sabine; Huss-Marp, Johannes; Dorn, Britta; Biedermann, Tilo; Lidholm, Jonas; Rücker, Gerta; Bantleon, Frank I.; Miehe, Michaela; Spillner, Edzard; Thilo, Jakob. In: Journal of Allergy and Clinical Immunology, Vol. 138, No. 6, 2016.

Preparation and Characterization og Human Milk Fat Substitutes Based on Triacylglycerol Profiles. / Zou, Xiaoqiang; Jin, Qingzhe; Guo, Zheng; Xu, Xuebing; Wang, Xingguo. In: Journal of the American Oil Chemists' Society, Vol. 93, No. 6, 2016.

Preparation, functional characterization and hemostatic mechanism discussion for oxidized microcrystalline cellulose and its composites. / Cheng, Weilu; He, Jinmei; Chen, Menglin; Li, Dalong; Li, Hui; Chen, Lei; Cao, Ye; Wang, Jing; Huang, Yudong. In: Fibers and Polymers, Vol. 17, No. 8, 2016.

Processing of surface-nuclear magnetic resonance data from sites with high noise levels. / Larsen, Jakob Juul; Behroozmand, Ahmad A. In: Geophysics, Vol. 81, No. 4, 2016.

Production of conjugated linoleic acid-rich cottonseed oil by supported Ru catalyzed isomerization. / Liu, Shulai; Wang, Zegau; Xu, Xuebing; Ding, Yuting; Guo, Zheng. In: Industrial Crops and Products, Vol. 97, 2016.

Raising an Antibody Specific to Breast Cancer Subpopulations Using Phage Display on Tissue Sections. / Larsen, Simon Asbjørn; Meldgaard, Theresa; Fridriksdottir, Agla Jael Rubner; Lykkemark, Simon; Poulsen, Pi Camilla; Overgaard, Laura Falkensteen; Petersen, Helene Bundgaard; Petersen, Ole William; Kristensen, Peter. In: Cancer Genomics & Proteomics, Vol. 13, No. 1, 2016.

Reading Damaged Scripts: Partial Packet Recovery Based on Compressive Sensing for Efficient Random Linear Coded Transmission. / Mohammadi, Mohammad Sadegh; Zhang, Qi; Dutkiewicz, Eryk. In: IEEE Transactions on Communications, Vol. 64, No. 8, 2016.

Real-time hybrid simulation technique for performance evaluation of full-scale sloshing dampers in wind turbines. / Zhang, Zili; Basu, Biswajit; Nielsen, Søren R. K. In: Journal of Physics: Conference Series (Online), Vol. 753, 2016.

Reference configurations for Ear-EEG steady-state responses. / Kappel, Simon; Christensen, Christian Bech; Mikkelsen, Kaare; Kidmose, Preben. In: IEEE Engineering in Medicine and Biology Society, Conference Proceedings, 2016.

Revisiting Morrison and Osterle 1965 : the efficiency of membrane-based electrokinetic energy concersion. / Catalano, Jacopo; Hamelers, H. V. M.; Bentien, Anders; Biesheuvel, P. M. In: Journal of Physics: Condensed Matter, Vol. 28, No. 32, 2016.

Role for nucleotide-binding oligomerization domain 1 (NOD1) in pericyte-mediated vascular inflammation. / Navarro, Rocio; Delgado-Wicke, Pablo; Nuñez-Prado, Natalia; Compte, Marta; Blanco-Toribio, Ana; Nuñez , Gabriel; Álvarez-Vallina, Luis; Sanz, Laura. In: Journal of Cellular and Molecular Medicine, Vol. 20, No. 5, 2016.

Rule-based Dynamic Safety Monitoring for Mobile Robots. / Adam, Marian Sorin ; Larsen, Morten; Jensen, Kjeld; Schultz, Ulrik Pagh. In: Journal of Software Engineering for Robotics, Vol. 7, No. 1 .2016.

Seasonal differences in tillage draught on a sandy loam soil with long-term additions of animal manure and mineral fertilizers. / Peltre, Clément; Nyord, Tavs; Christensen, Bent Tolstrup; Jensen, Johannes; Thomsen, Ingrid Kaag; Munkholm, Lars Juhl. In: Soil Use and Management, Vol. 32, No. 4 .2016.

Seasonal variation of atmospheric particle number concentrations, new particle formation and atmospheric oxidation capacity at the high Arctic site Villum Research Station, Station Nord. / Nguyen, Quynh T.; Glasius,

Marianne; Sørensen, Lise L.; Jensen, Bjarne; Skov, Henrik; Birmili, Wolfram; Wiedensohler, Alfred; Kristensson, Adam; Nøjgaard, Jacob K.; Massling, Andreas. In: Atmospheric Chemistry and Physics, Vol. 16, No. 17, 2016.

Sensor and control for consistent seed drill coulter depth. / Kirkegaard Nielsen, Søren; Nørremark, Michael; Green, Ole. In: Computers and Electronics in Agriculture, Vol. 127, 2016.

Shape Analysis of PCCC Shell Structure by Geometrical Features – A Stable Shell Structure between Cylinder and PCCP Shell. / Suzuki, Hirotaka; Kirkegaard, Poul Henning; Odaka, Naoki. In: Researchgate, 2016.

Simulation of heterogeneous molecular delivery in tumours using μCT reconstructions and MRI validation. / Wittenborn, Thomas Rea; Nielsen, Thomas; Thomsen, Jesper Skovhus; Horsman, Michael Robert; Nygaard, Jens Vinge. In: Microvascular Research, Vol. 108, 2016.

Study of heat-stress levels in naturally ventilated sheep barns during heat waves: development and assessment of regression models. / Papanastasiou, D K; Bartzanas, T; Panagakis, P; Zhang, Guoqiang; Kittas, C. In: International Journal of Biometeorology, Vol. 60, No. 11, 2016.

Study on convective heat transfer from pig models by CFD in a virtual wind tunnel. / Li, Hao; Rong, Li; Zhang, Guoqiang. In: Computers and Electronics in Agriculture, Vol. 123, 2016.

Sulfonated Poly(Arylene Thioether Sulfone) Cation Exchange Membranes with Improved Permselectivity/Ion Conductivity Trade-Off. / Kristensen, Mette Birch; Haldrup, Sofie; Rask Christensen, Jonas; Catalano, Jacopo; Bentien, Anders. In: Journal of Membrane Science, Vol. 520, 2016.

Summary of best guidelines and validation of CFD modeling in livestock buildings to ensure prediction quality. / Rong, Li; Nielsen, Peter V.; Bjerg, Bjarne; Zhang, Guoqiang. In: Computers and Electronics in Agriculture, Vol. 121, 2016.

Supporting Denmark's District Heating and Cooling Networks by an Innovative Bifunctional Solar Assisted Absorption Chiller. / Arabkoohsar, Ahmad; Andresen, Gorm. In: Energy Conversion and Management, 2016.

Surgical Repair of Annulus Defect with Biomimetic Multilamellar Nano/microfibrous Scaffold in a Porcine Model. / Kang, Ran; Li, Haisheng; Peng, Xizhi; Ringgaard, Steffen; Baatrup, Anette; Rickers, Kresten; Sun, Ming; Le, Dang Quang Svend; Wang, Miao; Xie, Lin; Chen, Menglin; Bünger, Cody. In: Journal of Tissue Engineering and Regenerative Medicine, 2016.

Symmetry based frequency domain processing to remove harmonic noise from surface nuclear magnetic resonance measurements. / Hein, Annette; Larsen, Jakob Juul; D. Parsekian, Andrew. In: Geophysical Journal International, Vol. 208, No. 2, 2016.

Synthesis of silicon-doped reduced graphene oxide and its applications in dye-sensitive solar cells and supercapacitors. / Wang, Zegao; Chen, Yuanfu ; Li, Pingjian ; He, Jiarui ; Zhang, Wanli; Guo, Zheng; Li, Yanrong ; Dong, Mingdong. In: RSC Advances, Vol. 6, No. 18, 2016.

Synthetic ultra-long chain fatty acyl based amphiphilic lipids as a dual function excipient for the production of surfactant-free solid lipid nanoparticles (SF-SLNs): a physico-chemical study. / Wei, Wei; Lu, Xiaonan; Wang, Zegao; Dong, Mingdong; Feng, Fengqin; Guo, Zheng. In: Green Chemistry, Vol. 18, 2016.

Tailoring Membrane Nanostructure and Charge Density for High Electrokinetic Energy Conversion Efficiency. / Haldrup, Sofie; Catalano, Jacopo; Hinge, Mogens; Jensen, Grethe Vestergaard; Pedersen, Jan Skov; Bentien, Anders. In: ACS NANO, Vol. 10, No. 2, 2016.

The correctness of event-B inductive convergence. / Hallerstede, Stefan. In: Science of Computer Programming, Vol. 131, 2016.

The Development and Application of Two-Chamber Reactors and Carbon Monoxide Precursors for Safe Carbonylation Reactions. / Friis, Stig D.; Lindhardt, Anders T.; Skrydstrup, Troels. In: Accounts of Chemical Research, Vol. 49, No. 4, 2016.

The effect of harvest time, dry matter content and mechanical pretreatments on anaerobic digestion and enzymatic hydrolysis of miscanthus. / Nielsen, Susanne Frydendal; Hjorth, Maibritt; Baby, Sanmohan; Felby, Claus; Jørgensen, Uffe; Gislum, René. In: Bioresource Technology, Vol. 218, 2016.

The effect of increased classroom ventilation rate indicated by reduced CO2-concentration on the performance of schoolwork by children. / Petersen, Steffen; Jensen, K L.; Pedersen, A. L. S.; Rasmussen, H. S. In: Indoor Air, Vol. 26, No. 3, 2016.

The effect of the aortic valve orientation on cavitation. / Johansen, Peter; Travis, Brandon Reed; Smerup, Morten Holdgaard; Christensen, Thomas Decker; Funder, Jonas Amstrup; Nyboe, Camilla; Nygaard, Hans; Hasenkam, J. Michael. In: IEEE Xplore, 2016.

The evolution of VDM tools from the 1990s to 2015 and the influence of CAMILA. / Larsen, Peter Gorm; Fitzgerald, John. In: Journal of Logical and Algebraic Methods in Programming, Vol. 85, No. 5, 2016.

The near-ideal catalytic property of Candida antarctica lipase A to highly concentrate n-3 polyunsaturated fatty acids in monoacylglycerols via one-step ethanolysis of triacylglycerols. / Yong-Jin, He; Li, Jingbo; Kodali, Sitharam; Chen, Bilian; Guo, Zheng. In: Bioresource Technology, Vol. 219, 2016.

The preparation of a recyclable catalyst of silver nanoparticles dispersed in mesoporous silica nanofiber matrix. / Li, Dalong; Dong, MD; Besenbacher, Flemming; Huang, Yudong; Chen, Menglin. In: RSC Advances, Vol. 6, 2016.

The role of collaborations in the development and implementation of sustainable livestock concepts in The Netherlands. / de Olde, Evelien; Carsjens, Gerrit-Jan; Eilers, Catharina H.A.M. In: International Journal of Agricultural Sustainability, 2016.

Three-dimensional polydopamine functionalized coiled microfibrous scaffolds enhance human mesenchymal stem cells colonization and mild myofibroblastic differentiation. / Taskin, Mehmet Berat; Xu, Ruodan; Gregersen, Hans; Nygaard, Jens Vinge; Besenbacher, Flemming; Chen, Menglin. In: ACS Applied Materials and Interfaces, Vol. 8, No. 25, 2016.

Treatment of swine manure : case studies in European's N-surplus areas. / Cruz Garcia-Gonzalez, Maria; Riano, Berta; Teresa, Marta; Herrero, Eva; Ward, Alastair James; Provolo, Giorgio; Moscatelli, Giuseppe; Piccinini, Sergio; Bonmati, August; Pilar Bernal, Maria; Wisniewska, Hanna; Proniewicz, Marcin. In: Scientia Agricola, Vol. 73, No. 5, 2016.

Ultralong Fatty Acyl Derivatives As Occlusive Structure Lipids for Cosmetic Applications : Synthesis and Characterization. / Pérez, Bianca; Bulsara, Pallav; Rawlings, Anothony Vincent; Wei, Wei; Jensen, Mads Mørk; Wang, Zegao; Dickens, Jason; Zhang, Shuai; Russell, P. Elliot; Glasius, Marianne; Dong, MD; Clarke, Martyn; Guo, Zheng. In: ACS Sustainable Chemistry & Engineering, Vol. 4, No. 12, 2016.

Unbiased solar energy storage : Photoelectrochemical redox flow battery. / Azevedo, João; Seipp, Thorsten; Burfeind, Jens; Sousa, Célia; Bentien, Anders; Araújo, João Pedro; Mendes, Adélio. In: Nano Energy, Vol. 22, 2016.

Upper limit for context-based crop classification in robotic weeding applications. / Midtiby, Henrik Skov; Åstrand, Björn; Jørgensen, Ole; Nyholm Jørgensen, Rasmus. In: Biosystems Engineering, Vol. 146, 2016.

Use of sugarcane bagasse with different particle sizes to determine the relationship between physical properties and enzymatic hydrolysis. / Li, Jingbo; Zhou, Pengfei; Lv, Xiaojing; Xiao, Wenjuan; Gong, Yingxue; Lin, Jianghai; Liu, Zehuan. In: BioResources, Vol. 11, No. 2, 2016.

Using Deep Learning to Challenge Safety Standard for Highly Autonomous Machines in Agriculture. / Steen, Kim Arild; Christiansen, Peter; Karstoft, Henrik; Nyholm Jørgensen, Rasmus. In: Journal of Imaging, Vol. 2, No 1, 2016.

Verifying the Co-Simulation Orchestration Engine for INTO-CPS. / Thule, Casper. In: CEUR Workshop Proceedings, Vol. 1744, 2016.

When experts disagree: the need to rethink indicator selection for assessing sustainability of agriculture. / de Olde, Evelien M.; Moller, Henrik; Marchand, Fleur; McDowell, Richard W.; MacLeod, Catriona J.; Sautier, Marion; Halloy, Stephan; Barber, Andrew; Benge, Jayson; Bockstaller, Christian; Bokkers, Eddie A M; de Boer, Imke J M; Legun, Katharine A.; Le Quellec, Isabelle; Merfield, Charles; Oudshoorn, Frank W.; Reid, John; Schader, Christian; Szymanski, Erika; Sørensen, Claus A G; Whitehead, Jay; Manhire, Jon. In: Environment, Development and Sustainability, 2016.

Wide Span - Re-mechanising Vegetable Production. / Pedersen, Hans Henrik; Oudshoorn, Frank W; McPhee, J E; Chamen, W C T. In: Acta Horticulturae, Vol. 1130, 2016.

CONTRIBUTIONS TO BOOKS AND REPORTS

A model-driven evaluation of demand response communication protocols for smart grid. / Ebeid, Emad Samuel Malki; Rotger Griful, Sergi; Mikkelsen, Søren Aagaard; Jacobsen, Rune Hylsberg. In: Smarter Energy: From Smart Metering to the Smart Grid. Part III: Smart grid communications and networking IET. The Institution of Engineering and Technology. 2016.

Blood Pressure Self-Measurement. / Wagner, Stefan Rahr. In: Advances in Experimental Medicine and Biology. 2016.

Building Stock Distribution and Electricity Use for Lighting. / Dubois, Marie-Claude ; de Boer, Jan ; Deneyer, Arnaud; Fuhrmann, Peter; Geisler-Moroder, David ; Hoier, Anna ; Jakobiak, Roman; Knoop, Martine ; Koga, Yasuko; Osterhaus, Werner; Paule, Bernard; Pertola, Peter; Stoffer, Sophie; Tetri, Eino. In: A Technical Report of Subtask D (Case Studies), T50 .D1: IEA SHC Task 50: Advanced Lighting Solutions for Retrofitting Buildings. 2016.

Collaborative Modeling and Simulation for Cyber-Physical Systems. / Larsen, Peter Gorm; Fitzgerald, John; Woodcock, Jim; Lecomte, Thierry. In: Trustworthy Cyber-Physical Systems Engineering. 2016.

Daylighting and Lighting Retrofit to Reduce Energy Use in Non-Residential Buildings : A Literature Review. / Dubois, Marie-Claude ; Gentile, Niko ; Bisegna, Fabio ; Knoop, Martine ; Matusiak, Barbara ; Osterhaus, Werner; Tetri, Eino. In: IEA SHC Task 50: Advanced Lighting Solutions for Retrofitting Buildings. 2016.

Developing a new management tool – a holistic view on the Nitrogen cycle. / Geels, Camilla; Hansen, Kaj Mantzius; Andersen, Hans Estrup; Thodsen, Hans; Trolle, Dennis; Bolding, Karsten; Hasler, Berit; Zandersen, Marianne; Gyldenkœrne, Steen; Nyord, Tavs; Timmermann, Karen. In: Air Pollution Modelling and its Application XXIV. 2016.

Electro-Magnetic Nano Positioning. / Zhang, Zhuo; Yu, Yueqing; Liu, Xinyu; Zhang, Xuping. In: Nanopositioning Technologies: Fundamentals and Applications. 2016.

Flow Boiling Heat Transfer with Models in Microchannels. / Cheng, Lixin. In: Microchannel Phase Change Transport Phenomena, 2016.

Flow Patterns and Bubble Growth in Microchannels. / Cheng, Lixin. In: Microchannel Phase Change Transport Phenomena. 2016.

IgE als Zielstruktur für therapeutische Intervention. / Jakob, Thilo; Spillner, Edzard; Lamers, Marinus. In: Allergologie. 2016.

Infrastructure Estimates for a Highly Renewable Global Electricity Grid. / Dahl, Magnus; Rodriguez, Rolando A.; Søndergaard, Anders Aspegren; Zeyer, Timo; Andresen, Gorm; Greiner, Martin. In: New Horizons in Fundamental Physics. 2016.

Ionic Liquids in Lipid Analysis. / Li, Jingbo. In: Ionic Liquids in Lipid Processing and Analysis: Opportunities and Challenges. 2016.

Lesson's Learned from monitoring daylighting in retrofit projects. / Amorim, Cláudia Naves David; Dubois, Marie-Claude ; Gentile, Niko ; Osterhaus, Werner; Stoffer, Sophie; Jakobiak, Roman; Geisler-Moroder, David; Matusiak, Barbara. Int: A Technical Report of IEA SHC Task 50. 2016.

Modelling turbulent time series by BSS-processes. / Urbina, José Ulises Márquez; Schmiegel, Jürgen. In: The Fascination of Probability, Statistics and their Applications: In Honour of Ole Barndorff-Nielsen. 2016.

Monitoring Protocol for Lighting and Daylighting Retrofits. / Dubois, Marie-Claude ; Gentile, Niko ; Amorim, Cláudia Naves David ; Geisler-Moroder, David ; Jakobiak, Roman; Matusiak, Barbara ; Osterhaus, Werner; Stoffer, Sophie. In: A Technical Report of IEA SHC Task 50. 2016.

Pd-Catalyzed Carbonylative Synthesis of Other-Membered Heterocycles from Aryl Halides. / Nielsen, Dennis Ulsøe; Lian, Zhong; Lindhardt, Anders Thyboe; Skrydstrup, Troels. In: Topics in Heterocyclic Chemistry: Transition Metal Catalyzed Carbonylative Synthesis of Heterocycles. Vol. 42, 2016.

Power Flow Tracing in Complex Networks. / Schäfer, Mirko; Hempel, Sabrina; Hörsch, Jonas; Tranberg, Bo; Schramm, Stefan; Greiner, Martin. In: New Horizons in Fundamental Physics. 2016.

Securing a Home Energy Managing Platform. / Mikkelsen, Søren Aagaard; Jacobsen, Rune Hylsberg. In: Energy Management of Distributed Generation Systems. 2016.

Some recent developments in Ambit Stochastics. / Barndorff-Nielsen, Ole E.; Hedevang, Emil; Schmiegel, Jürgen; Szozda, Benedykt. In: Stochastics of Environmental and Financial Economics. Vol. 138, 2016.

CONTRIBUTIONS TO CONFERENCE PROCEEDINGS

A 1.62 µW 8-Channel Ultra-High Input Impedance EEG Amplifier for Dry and Non-Contact Biopotential Recording Applications. / Nasserian, Mahshid; Peiravi, Ali; Moradi, Farshad. 2016 IFIP/IEEE International Conference on Very Large Scale Integration: VSLI-SOC. 2016.

A Case Study of Heave of Pile-Supported Structures Due to Pile Driving in Heavily Overconsolidated Very High Plasticity Palaeogene Clay. / Hørlykke, T; Dedenroth, B; Sørensen, Kenny Kataoka. Proceedings of 17th Nordic Geotechnical Meeting: NGM 2016 - Challenges in Nordic Geotechnics. 2016.

A Case Study of the Interaction between a Pile and Soft Soil focusing on Negative Skin Friction using Finite Element Analysis. / Belinchon, P; Sørensen, Kenny Kataoka; Christensen, Rune. Proceedings of 17th Nordic Geotechnical Meeting: NGM 2016 - Challenges in Nordic Geotechnics. 2016.

A Formal Framework for Modeling Smart Grid Applications: Demand Response Case Study. / Ghasem Azar, Armin; Ebeid, Emad Samuel Malki; Jacobsen, Rune Hylsberg. Proceedings of the 19th Euromicro Conference on Digital System Design (DSD 2016). 2016.

A Low-Power Analog Front-End Neural Acquisition Design for Seizure Detection. / Tohidi, Mohammad; Madsen, Jens Kargaard; Heck, Martijn; Moradi, Farshad. 2016 IFIP/IEEE International Conference on Very Large Scale Integration: VSLI-SOC. 2016.

A Low-Power Time-Based Phase-Domain Analog-to-Digital Converter. / Assarzadeh, Mina; Saberi, Mehdi; Tohidi, Mohammad; Moradi, Farshad. 23rd IEEE International Conference on Electronics Circuits and Systems (ICECS) 2016: ICECS 2016. 2016.

A Method for Modeling Flexible Manipulators: Transfer Matrix Method with Finite Segments. / Zhang, Haijie Li; Xuping, Zhang. ICCAR 2016: 18th International Conference on Control, Automation and Robotics. 2016.

A Methodology for Quality Control and Draught Assessment of Room Ventilation Supply Using Laser Light Sheets. / Hviid, Christian Anker; Petersen, Steffen. CLIMA 2016 - Proceedings of the 12th REHVA World Congress. 2016.

A Multicore Fiber Sensor for Monitoring Twists of Wind Turbine Parts. / Kristensen, Martin; Nielsen, Lars; Glavind, Lars. Photonics and Fiber Technology 2016 (ACOFT, BGPP, NP): OSA Technical Digest. Optical Society of American (OSA), 2016. BM5B.6. (Bragg Gratings, Photosensitivity, and Poling in Glass Waveguides). 2016.

A Wearable Ear-EEG Recording System Based on Dry-Contact Active Electrodes. / Zhou, Xiong; Li, Qiang; Kilsgaard, Søren; Moradi, Farshad; Kappel, Simon; Kidmose, Preben. 30th IEEE Symposium on VLSI Circuits, 2016.

Agent-based Charging Scheduling of Electric Vehicles. / Ghasem Azar, Armin; Jacobsen, Rune Hylsberg. IEEE Online Conference on Green Communications, 2016.

Agricultural robotic candidate overview using co-model driven development. / Christiansen, Martin Peter; Larsen, Peter Gorm; Nyholm Jørgensen, Rasmus. Proceedings of the 9th International Conference on Integrated Modeling and Analysis in Applied Control and Automation: IMAACA 2016. 2016.

Analysis of Wind-Induced Vibrations in High-Rise Buildings. / Persson, Peter; Austrell, Per-Erik; Kirkegaard, Poul Henning; Andersen, Lars Vabbersgaard; Steffen, Frederik. INTER-NOISE 2016. 2016.

Anvendelse af data fra traktorens computer til bedriftsstyring. / Nørremark, Michael. Plantekongres 2016. 2016.

Applications of a heat load forecast with dynamic uncertainties. / Dahl, Magnus; Andresen, Gorm; Brun, Adam. 2nd International Conference on Smart Energy Systems and 4th Generation District Heating: Abstracts. 2016.

ARTMoS: An RFID tag mobility scheme with IPv6 and DNS. / Çabuk, Umut Can; Jacobsen, Rune Hylsberg; Dalkilic, Gökhan. Proceedings of the 2016 International Symposium on INnovations in Intelligent SysTems and Applications: INISTA. 2016.

Assessment of alternative heat source and storage integration in the district heating network of Aarhus using dynamic network simulations. / Marguerite, Charlotte; Schmidt, Ralf-Roman; Andresen, Gorm. 2nd International Conference on Smart Energy Systems and 4th Generation District Heating: Abstracts. 2016.

Automated Generation of C# and .NET Code Contracts from VDM-SL Models. / Diswal, Steffen P.; Tran-Jørgensen, Peter Würtz Vinther; Larsen, Peter Gorm. 14th Overture Workshop: Towards Analytic Tool Chains: Technical Report ECE-TR-28. Vol 4, No. 28. 2016.

Automated VDM-SL to Smalltalk Code Generators for Exploratory Modeling. / Oda, Tomohiro; Akari, Keijiro; Larsen, Peter Gorm. The 14th Overture Workshop: Towards Analytical Tool Chains: Technical Report ECE-TR-28. Vol. 4, No. 28. 2016.

Autonomous relaying scheme for energy-efficient cooperative multicast communications. / Li, Liying; Zhao, Guodong; Shi, Wuyu; Chen, Zhi; Zhang, Qi. 2016 IEEE Wireless Communications and Networking Conference: WCNC 2016. 2016.

Balancing User and System Control in Shape-Changing Interfaces : a Designerly Exploration. / Rasmussen, Majken Kirkegård; Merritt, Timothy Robert; Alonso, Miguel Bruns; Petersen, Marianne Graves. Proceedings of the TEI '16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction. 2016.

CoFELS: Conceptual Framework for Electricity Load Shifting System Design. / Kim, Jung Min; Jacobsen, Rune Hylsberg; Brewer, Robert S. Proceedings of the 19th Euromicro conference on Digital System Design: (DSD 2016). 2016.

Combining Harvesting Operation Optimisations using Strategy-based Simulation. / Couto, Luis Diogo; Tran-Jørgensen, Peter Würtz Vinther; Edwards, Gareth Thomas Charles. Proceedings of the 6th International Conference on Simulation and Modeling Methodologies, Technologies and Applications: SIMULTECH 2016. 2016.

Considering Abstraction Levels on a Case Study. / Thule, Casper; Nilsson, Rene. The 14th Overture Workshop: Towards Analytical Tool Chains: Technical Report ECE-TR-28. Vol. 4, No. 28. 2016.

Data Quality Oriented Efficacy Evaluation Method for Ambient Assisted Living Technologies. / Beevi, Femina Hassan Aysha; Wagner, Stefan Rahr; Pedersen, Christian Fischer; Hallerstede, Stefan. Proceedings of the 10th EAI International Conference on Pervasive Computing Technologies for Healthcare, PervasiveHealth 2016. 2016.

Data Quality Oriented Taxonomy of Ambient Assisted Living Systems. / Beevi, Femina Hassan Aysha; Wagner, Stefan Rahr; Hallerstede, Stefan; Pedersen, Christian Fischer. IET International Conference on Technologies for Active and Assisted Living: TechAAL, 2015. 2016.

DB&A: An Open Source Web Service for Meter Data Management. / Mikkelsen, Søren Aagaard; Jacobsen, Rune Hylsberg; Terkelsen, Anders Franz. Proceedings of the 2016 IEEE Symposium on Service-Oriented System Engineering: SOSE 2016. 2016.

Decoupling validation UIs using Publish-Subscribe binding of instance variables in Overture. / Couto, Luis Diogo; Lausdahl, Kenneth Guldbrandt; Plat, Nico; Larsen, Peter Gorm; Pierce, Ken. The 14th Overture Workshop: Towards Analytical Tool Chains: Technical Report ECE-TR-28. Vol. 4, No. 28. 2016.

Design of an Event-Driven Residential Demand Response Infrastructure. / Jacobsen, Rune Hylsberg; Ghasem Azar, Armin; Ebeid, Emad Samuel Malki. Proceedings of the 19th Euromicro Conference on Digital System Design : DSD 2016. 2016.

Designing for Children's Collective Music Making : How Spatial Orientation and Configuration Matter. / Grønbæk, Jens Emil; Jakobsen, Kasper; Petersen, Marianne Graves; Rasmussen, Majken Kirkegård; Winge, Jakob ; Stougaard, Jeppe. NordiCHI '16 Proceedings of the 9th Nordic Conference on Human-Computer Interaction. 2016.

Desktop polling station for real-time building occupant feedback. / Petersen, Steffen; Pedersen, Stine. CLIMA 2016 - Proceedings of the 12th REHVA World Congress. Vol. 7, 2016.

Despiking of Surface-NMR Data Using a Model-based Approach. / Larsen, Jakob Juul. Near Surface Geoscience 2016 : 22nd European Meeting of Environmental and Engineering Geophysics. 2016.

Development of electrostatic precipitators for small biomass-fired boilers. / Kristensen, Erik Fløjgaard; Kristensen, Jens Kristian; Speiermann, Martin; Linnemann, Niels. Proceedings of the 24th European Biomass Conference and Exhibition. 2016.

Direct and indirect heating network energy savings from building retrofit. / Pedersen, Rasmus Høst; Kristensen, Martin Heine; Petersen, Steffen; Brun, Adam; Andresen, Gorm. 2nd International Conference on Smart Energy Systems and 4th Generation District Heating: Abstracts. 2016.

Does embodied energy in windows affect their energy-efficiency ranking? / Kristensen, Martin Heine; Petersen, Steffen. CLIMA 2016 - Proceedings of the 12th REHVA World Congress. Vol. 2, 2016.

Doubling the spectrum of time-domain induced polarization by harmonic de-noising, drift/spike removal and tapered gating. / Fiandaca, G.; Olsson, P. I.; Larsen, Jakob Juul; Dahlin, T.; Auken, E. 22nd European Meeting of Environmental and Engineering Geophysics, Near Surface Geoscience 2016. 2016.

Dynamic Electro-thermal Modeling of V- and Z-shaped Electrothermal Microactuator. / Zhang, Zhuo; Yu, Yueqing; Liu, Xinyu; Zhang, Xuping. Proceedings of the 2016 IEEE International Conference on Mechatronics and Automation: ICMA. 2016.

Evaluation of Caregivers' First Time Use of a Seamless Deployment Platform. / Wagner, Stefan Rahr; Beevi, Femina Hassan Aysha; Pedersen, Christian Fischer; Miranda, Jorge; Cabral, Jorge; Ravelo, Blaise. Proceedings of the International Conference e-Health 2016. 2016.

Evaluation of Range-based Methods for Localization in Grain Storages. / Juul, Jakob Pilegaard; Green, Ole; Jacobsen, Rune Hylsberg. Proceedings of the 5th International Conference on Sensor Networks: SENSORNETS 2016. 2016.

Experimental Assessment of Mechanical Night Ventilation on Inner Wall Surfaces. / Ji, Wenhui; Heiselberg, Per Kvols; Wang, Houhua; Hu, Yue; Zhang, Zili. CLIMA 2016 - Proceedings of the 12th REHVA World Congress. 2016.

Experimental study of cracks at interfaces with voids. / Budzik, Michal Kazimierz; Jensen, Henrik Myhre. Procedia Structural Integrity: 21st European Conference on Fracture, ECF21. Vol. 2, 2016.

Expressivity in Open-ended Constructive Play: Building and Playing Musical Lego Instruments. / Jakobsen, Kasper; Stougaard, Jeppe; Petersen, Marianne Graves; Winge, Jakob ; Grønbæk, Jens Emil; Rasmussen, Majken Kirkegård. IDC '16 Proceedings of the 15th International Conference on Interaction Design and Children. 2016.

Facilitating Industrial Placement in the Construction Engineering Curriculum. / Wandahl, Søren; Ussing, Lene Faber. Construction Research Congress 2016: Old and New Construction Technologies Converge in Historic San Juan. 2016.

Faste kørespor, pløjefri dyrkning og radrensning. / Nørremark, Michael. Plantekongres 2016. 2016.

Field measurements of pore water pressure changes in very high plasticity stiff clays adjacent to driven piles. / Simonsen, Thomas Rye; Sørensen, Kenny Kataoka. Proceedings of the 17th Nordic Geotechnical Meeting: NGM 2016 - Challenges in Nordic Geotechnics. 2016.

Formalising and Validating the Interface Description in the FMI standard. / Hasanagic, Miran; Tran-Jørgensen, Peter Würtz Vinther; Lausdahl, Kenneth Guldbrandt; Larsen, Peter Gorm. FM 2016: Formal Methods: Proceedings of the 21st International Symposium on Formal Methods. Vol. 9995, 2016.

Generating Event-B Specifications from Algorithm Descriptions. / Clark, Joy; Bendisposto, Jens; Hallerstede, Stefan; Hansen, Dominik; Leuschel, Michael. Abstract State Machines, Alloy, B, TLA, VDM, and Z: ABZ 2016. Vol. 9675, 2016.

Grid integration of solar PV and electrical vehicles for multi-apartment buildings. / Andresen, Gorm; Kozarcanin, Smail. 2nd International Conference on Smart Energy Systems and 4th Generation District Heating: Abstracts. 2016.

Handling Stochastic Occupancy in an Economic Model Predictive Control Framework for Heating System Operation in Dwellings. / Pedersen, Theis; Knudsen, Michael Dahl; Hedegaard, Rasmus Elbæk; Petersen, Steffen. CLIMA 2016 - Proceedings of the 12th REHVA World Congress. Vol. 10, 2016.

Hardware-in-the-Loop Co-simulation of Distribution Grid for Demand Response. / Rotger Griful, Sergi; Chatzivasileiadis, Spyros ; Jacobsen, Rune Hylsberg; Stewart, Emma M. ; Domingo, Javier Matanza ; Wetter, Michael. Power Systems Computation Conference (PSCC), 2016.2016.

High diagnostic quality ECG compression and CS Signal reconstruction in body sensor networks. / Chidean, Mihaela I.; Barquero-Pérez, Óscar; Zhang, Qi; Jacobsen, Rune Hylsberg; Caamano, Antonio J. 2016 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP 2016) . 2016.

Identifying a Comfortable Excitation Signal for Generating Building Models for Model Predictive Control : A Simulation Study. / Hedegaard, Rasmus Elbæk; Pedersen, Theis; Knudsen, Michael Dahl; Petersen, Steffen. CLIMA 2016 - Proceedings of the 12th REHVA World Congress. Vol. 10, 2016.

Impression Evaluation of Paper Folding Lampshade by Danish Students. / Odaka, Naoki; Suzuki, Hirotaka; Kirkegaard, Poul Henning; Osterhaus, Werner; Okamura, Atsumi. 17th International Conference on Geometry and Graphics. 2016.

Impression Evaluation of Paper Folding Lamp Shade by Japanese Students and Comparison with Results by Danish Students. / Okamura, Atsumi; Odaka, Naoki; Suzuki, Hirotaka; Kirkegaard, Poul Henning; Osterhaus, Werner. 17th International Conference on Geometry and Graphics. 2016.

Integrated Tool Chain for Model-Based Design of Cyber-Physical Systems. / Larsen, Peter Gorm; Thule, Casper; Lausdahl, Kenneth Guldbrandt; Bandur, Victor; Gamble, Carl; Brosse, Etienne; Sadovykh, Andrey; Bagnato, Alessandra; Couto, Luis Diogo. The 14th Overture Workshop: Towards Analytical Tool Chains: Technical report ECE-TR-28. Vol. 4, No. 28, 2016.

Integrated tool chain for model-based design of Cyber-Physical Systems: The INTO-CPS project. / Larsen, Peter Gorm; Fitzgerald, John; Woodcock, Jim; Fritzson, Peter; Brauer, Jörg; Kleijn, Christian; Lecomte, Thierry; Pfeil, Markus; Green, Ole ; Basagiannis, Stylianos; Sadovykh, Andrey. 2016 2nd International Workshop on Modelling, Analysis, and Control of Complex CPS (CPS Data). 2016.

Investigating Concurrency in the Co-Simulation Orchestration Engine for INTO-CPS. / Thule, Casper; Larsen, Peter Gorm. Preliminary Proceedings of the 10th Spring/Summer Young Researchers' Colloquium on Software Engineering (SYRCoSE 2016). 2016.

Investigating the Ability of Prevailing Thermal Comfort Models to Predict Thermal Comfort in Homes. / Petersen, Steffen; H. Clausen, Anders; D.S.Knudsen, Lasse. CLIMA 2016 - Proceedings of the 12th REHVA World Congress. Vol. 7, 2016.

Large Electroviscous Effects in Sulfonated Polymeric Membranes. / Kristensen, Mette Birch; Haldrup, Sofie; Christensen, J. Rask; Catalano, Jacopo; Bentien, Anders. 2016. Book of Abstracts, PERMEA & MELPRO Conference 2016. 2016.

Legal Aspects Connected to the Use of BIM in the Danish Building Sector. / Ussing, Lene Faber; Svidt, Kjeld; Wandahl, Søren. Construction Research Congress 2016: Old and New Construction Technologies Converge in Historic San Juan. 2016.

Lessons learned from a qualitative sustainability assessment method "Farm Talks". / de Olde, Evelien; Derkzen, Petra ; Oudshoorn, Frank Willem; Sørensen, Claus Aage Grøn. 12th European IFSA Symposium : Social and technological transformation of farming systems: Diverging and converging pathways. 2016.

Low-Power Comparator in 65-nm CMOS with Reduced Delay Time. / Tohidi, Mohammad; Madsen, Jens Kargaard; Heck, Martijn; Moradi, Farshad. 23rd IEEE International Conference on Electronics, Circuits and Systems: ICECS 2016. 2016.

Model Predictive Control of Space Heating and the Impact of Taxes on Demand Response : A Simulation Study. / Knudsen, Michael Dahl; Hedegaard, Rasmus Elbæk; Petersen, Steffen; Pedersen, Theis. CLIMA 2016 - Proceedings of the 12th REHVA World Congress. Vol. 10, 2016.

Model-Driven Design Approach for Building Smart Grid Applications. / Ebeid, Emad Samuel Malki; Valov, Martin; Jacobsen, Rune Hylsberg. Proceedings of the 19th Euromicro Conference on Digital System Design: (DSD 2016). 2016.

Modelling changes in the dynamic response of a cantilever beam during the machining process using the discrete element method. / Andersen, Anders H.; Ringgaard, Kasper; Balling, Ole. ASME 2016 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference : 28th Conference on Mechanical Vibration and Noise, Vol. 8, 2016.

Modelling Collaborative Systems and Automated Negotiations. / Plat, Nico; Larsen, Peter Gorm; Pierce, Ken. The 14th Overture Workshop: Towards Analytical Tool Chains: Technical Report ECE-TR-28. Vol. 4, No. 28. 2016.

Modelling of Material Removal on Large Wind Turbine Hub. / Ringgaard, Kasper; Balling, Ole. Proceedings of the 4th Joint International Conference on Multibody System Dynamics: IMSD. 2016.

Multi-modal Building Energy Management System for Residential Demand Response. / Rotger Griful, Sergi; Welling, Ubbe; Jacobsen, Rune Hylsberg. Proceedings of the 19th Euromicro Conference on Digital System Design: (DSD 2016). 2016.

NILM-Based Authorization Framework for Improved User Consent. / Mikkelsen, Søren Aagaard; Jacobsen, Rune Hylsberg. Proceedings of the Work in Progress Session held in connection with DSD 2016. 2016.

Oedometer tests with measurement of internal friction between oedometer ring and clay specimen. / Lodahl, Michael Rosenlund; Sørensen, Kenny Kataoka; Mortensen, Niels; Trankjær, Helle. Proceedings of the 17th Nordic Geotechnical Meeting: NGM 2016 - Challenges in Nordic Geotechnics. 2016.

OMA Identification of a wind turbine rotor hub for monitoring purpose. / Juul, Martin Ørum Ørhem; Kovacs, Emese; Brincker, Rune; Balling, Ole. Proceedings of the 2016 Leuven Conference on Noise and Vibration Engineering, International Conference on Noise and Vibration Engineering: ISMA 2016-USD2016. 2016.

Optimal Membrane Nanostructure for Electrokinectic Energy Conversion. / Haldrup, Sofie; Kristensen, Mette Birch; Østedgaard-Munck, David Nicolas; Catalano, Jacopo; Bentien, Anders. 2016. Book of Abstracts, PERMEA & MELPRO Conference 2016. 2016.

Photonic integrated circuits : a new eco-system, a new paradigm. / Heck, Martijn. DOPS Annual Meeting 2016: Book of Abstracts. 2016.

Potential for Square Wave Transmitters in Surface NMR. / Grombacher, Denys James; Larsen, Jakob Juul; Auken, Esben. Near Surface Geoscience 2016: 22nd European Meeting of Environmental and Engineering Geophysics. Vol. 2016, 2016.

Presenting user behavior from main meter data. / Ebeid, Emad Samuel Malki; Heick, Rune; Jacobsen, Rune Hylsberg. 2016 IEEE International Conference on Smart Grid Communications (SmartGridComm). Vol. 2016. 2016.

Principles for Reuse in Formal Language Tools. / Couto, Luis Diogo; Tran-Jørgensen, Peter Würtz Vinther; Lausdahl, Kenneth Guldbrandt. Proceedings of the 31st ACM Symposium on Applied Computing. 2016.

Recombinant allergens as a major step in molecular allergology: Scientific and methodological considerations. / Spillner, Edzard. Slovenian Pneumology and Allergology Congress joined with Golnik Symposium and Balkan Pneumology Meeting: Personalised Medicine in Respiratory and Immunologic Diseases - Book of Abstacts. 2016.

Research and Development Activities on Pile Foundations in Europe. / Gavin, Kenneth; Igoe, David; Sørensen, Kenny Kataoka, Huybrechts, Noël. Proceedings of ISSMGE - ETC 3 International Symposium on Design of Piles in Europe: How did Eurocode 7 change daily practice? 2016.

Robot-Supported Food Experiences : Exploring Aesthetic Plating with Design Prototypes. / Østergaard Laursen, Christian; Pedersen, Søren; Merritt, Timothy Robert; Caprani, Ole. Cultural Robotics: First International Workshop, CR 2015. 2016.

Robotic Tray-Handling in Medical Chewing Gum Production. / Zhang, Xuping; Heide-Jørgensen, Simon; Næsby Frederiksen, Kasper ; Helsinghoff, Nicolai; Li, Haijie ; Albertsen, Jacob. Proceedings of the 2nd World Congress on Mechanical, Chemical, and Material Engineering (MCM'16). 2016.

Si3N4 waveguide technology for broadband and ultra-low-loss photonic integrated circuits". / Heck, Martijn. Photonic integration: advanced materials, new technologies and applications: 1st School of Photonics. Abstract. 2016.

Simple Path-following Rider Model for Single-track Vehicles. / Jensen, M; Balling, Ole. Proceedings of the 4th Joint International Conference on Multibody System Dynamics. 2016.

Simulation of Natural Ventilation in the Early Design of Near Zero Energy Buildings. / Brix Purup, Pil; Petersen, Steffen. CLIMA 2016 - Proceedings of the 12th REHVA World Congress. Vol. 5, 2016.

Sketching Shape-changing Interfaces : Exploring Vocabulary, Metaphor Use, and Affordances. / Rasmussen, Majken Kirkegård; Troiano, Giovanni Maria; Petersen, Marianne Graves; Simonsen, Jakob G.; Hornbæk, Kasper. Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems: CHI'16. Vol. 2016, 2016.

Stereo and active-sensor data fusion for improved stereo block matching. / Suvei, Stefan-Daniel; Bodenhagen, Leon; Kiforenko, Lilita; Christiansen, Peter; Nyholm Jørgensen, Rasmus; Buch, Anders Glent; Krüger, Norbert. Image Analysis and Recognition: Proceedings of 13th International Conference ICIAR in Memory of Mohamed Kamel. Vol. 9730, 2016.

Tectonic design of timber gridshells. / G. Fernandez, Jorge; Kirkegaard, Poul Henning; Branco, Jorge M. World Conference on Timber Engineering: WCTE 2016. 2016.

The effects of increased bedroom air temperature on sleep and next-day mental performance. / Strøm-Tejsen, Peter; Mathiasen, Sigrid; Bach, Marlene; Petersen, Steffen. Proceedings Indoor Air 2016: The 14th International Conference of Indoor Air Quality and Climate. 2016.

The research-teaching nexus in information systems education : a case study. / Obwegeser, Nikolaus; Papadopoulos, Pantelis; Catalano, Jacopo. MCIS 2016 Proceedings. 2016.

The role of sustainability assessment tools in enhancing dialogue and joint learning in transdisciplinary research on dairy farming. / de Olde, Evelien; Oudshoorn, Frank Willem; Sørensen, Claus Aage Grøn. 12th European IFSA Symposium : Social and technological transformation of farming systems: Diverging and converging pathways. Abstract. 2016.

Thermal Comfort Performance of a suspended ceiling system with non-perforated tiles as diffuse ventilation air inlet. / Petersen, Steffen; Persson, Torbjörn. CLIMA 2016 - Proceedings of the 12th REHVA World Congress. Vol. 5, 2016.

Towards Future Reliable Pervasive Healthcare with Adherence Strategy Engineering. / Wagner, Stefan Rahr. Proceedings of the 10th EAI International Conference on Pervasive Computing Technologies for Healthcare, PervasiveHealth 2016: Future of Pervasive Health Workshop. 2016.

Towards integration of Overture into TASTE. / Fabbri, T.; Verhoef, M.; Bandur, Victor; Perrotin, M.; Tsiodras, T.; Larsen, Peter Gorm. The 14th Overture Workshop: Towards Analytical Tool Chains: ECE-TR-28. Vol. 4, No. 28, 2016.

Towards Semantically Integrated Models and Tools for Cyber-Physical Systems Design. / Larsen, Peter Gorm; Fitzgerald, John; Woodcock, Jim; Nilsson, Rene; Gamble, Carl; Foster, Simon. Leveraging Applications of Formal Methods, Verification and Validation: Discussion, Dissemination, Applications: 7th International Symposium, ISoLA 2016, Proceedings, Part II. 2016.

Udviklingen inden for præcisionsjordbrug og tilknyttet udstyr. / Green, Ole; Edwards, Gareth Thomas Charles; Jæger, Claes D.; Steen, Kim Arild; Christensen, Peter; Dyrmann, Mads; Nyholm Jørgensen, Rasmus. Plantekongres 2016. 2016.

Unfolding Utzon - Learning from Utzon's architectural acoustic master pieces. / Kirkegaard, Poul Henning; Gisladottir, Arnthrudur. INTER-NOISE 2016. 2016.

Urban Tranquility – Towards immersive representation of noise and well-being in urban environments. / Kirkegaard, Poul Henning; Gisladottir, Arnthrudur. INTER-NOISE 2016. 2016.

Using games to support multi-stakeholder decision-making for sustainable development of livestock production. / de Olde, Evelien; de Boer, I J M. Farming Systems Facing Global Challenges: Capacities and Strategies: 11th European IFSA Symposium. 2016.

Using JML-based Code Generation to Enhance Test Automation for VDM Models. / Tran-Jørgensen, Peter Würtz Vinther; Larsen, Peter Gorm; Battle, Nick. 14th Overture Workshop: Towards Analytic Tool Chains: Technical report ECE-TR- 28. Vol. 4, No. 28, 2016.

ViennaTalk and Assertch : Building Lightweight Formal Methods Environments on Pharo 4. / Oda, Tomohiro; Akari, Keijiro; Larsen, Peter Gorm. Proceedings of the 11th edition of the International Workshop on Smalltalk Technologies (IWST 2016): In conjunction with the 24th International Smalltalk Joint Conference. 2016.

OTHER CONFERENCE CONTRIBUTIONS

A novel cormatrix pulmonary valve - initial in-vivo experience. / Rasmussen, Jonas; Skov, Søren Nielsen; Tjørnild, Marcell Juan; Nielsen, Ditte B.; Jensen, Ida L.; Johansen, Peter; Hjortdal, Vibeke E. Abstract from the 26th Annual Meeting SSRCTS. 2016.

A Novel Nondestructive Bit-Line Discharging Scheme for Deep Submicrometer STT-RAM. / Zeinali, Behzad; Madsen, Jens Kargaard; Raghavan, Praveen; Moradi, Farshad. Paper presented at the 34th IEEE International Conference on Computer Design. 2016.

A Step Towards Understanding Electromethanogenesis. / Yee, Mon Oo; Maegaard, Karen; Revsbech, Niels Peter; Thamdrup, Bo; Ottosen, Lars Ditlev Mørck; Rotaru, Amelia-Elena. Poster presented at the 3rd European Meeting of the International Society for Microbial Electrochemistry and Technology. 2016.

An integrated modelling approach to assess adaptation potentials for cattle housing climate. / Hempel, S.; Janke, D.; König, M.; Menz, C.; Pinto, S.; Sibony, V.; Rong, Li; Sanchis, E.; Galan, E.; Amon, T. Abstract from the International Conference Agricultural Engineering 2016. 2016.

Antioxidant Activity and Chemical Composition of Extracts from Different Processed Rapeseed Waste Gums. / Li, Jingbo; Guo, Zheng. Abstract from the 107th AOCS Annual Meeting & Expo. 2016.

Application of Advanced Oxidation Processes for Treatment of Air from Livestock Facilities. / Yao, Hongqing; Feilberg, Anders. Abstract from the International Conference Agricultural Engineering 2016. 2016.

Are dairy farmers willing to invest in technology to detect lameness? / de Olde, Evelien; Jensen, Allan Leck; Oudshoorn, Frank Willem; Sørensen, Claus Aage Grøn. Abstract from the International Conference on Agricultural Engineering 2016. 2016.

Assessing Energy Potentials of Agricultural Residues in Bangladesh : A Methodological Approach. / Rahman, Muhammad Anisur; Møller, Henrik Bjarne; Saha, Chayan Kumer; Monjurul Alam, Md. Paper presented at International Conference on Agricultural Engineering 2016. 2016.

Bias of Dynamic Olfactometry on the Chemical Composition of Odor Samples from Livestock Houses. / Lund Kasper, Pernille ; Mannebeck, Dietmar; Oxbøl, Arne; Feilberg, Anders. Abstract from the International Conference on Agricultural Engineering 2016. 2016.

Bio-degradation of veterinary antibiotics during the anaerobic digestion of pig manure. / Feng, Lu; Casas, Mònica Escolà; Bester, Kai; Ottosen, Lars Ditlev Mørck; Møller, Henrik Bjarne. Abstract from the International Conference on Agricultural Engineering 2016. 2016.

Biogas Production from Animal Manure and Poultry litter in Bangladesh. / Saha, Chayan Kumer; Sanaul Huda, Md.; Rahman, Muhammad Anisur; Møller, Henrik Bjarne; Monjurul Alam, Md. Paper presented at International Conference on Agricultural Engineering 2016. 2016.

Biomechanical description of the aortic root repair techniques - with supporting external annuloplasty. / Lading, Troels ; Lindskow, Thomas; Bechsgaard, Tommy Kragh; Røpcke, Diana Mathilde; Nygaard, Hans; Hasenkam, J. Michael; Johansen, Peter; Nielsen, Sten Lyager. Abstract from the 26th Annual Meeting SSRCTS. 2016.

Calibration of a cavity ring-down spectroscopy based analyzer in measuring ammonia from cattle barns. / Chowdhury, Albarune; Adamsen, Anders Peter S.; Feilberg, Anders. Abstract from the International Conference on Agricultural Engineering 2016. 2016.

Calming Children When Taking Blood Using Breath- based Biofeedback. / Sonne, Tobias; Merritt, Timothy Robert; Marshall, Paul; Lomholt, Johanne Jeppesen; Müller, Jörg; Grønbæk, Kaj. Paper. 2016.

CFD predictions of flow in agriculture buildings and summarization of best guidelines. / Rong, Li. Abstract from International Conference on Agricultural Engineering 2016. 2016.

Detecting epileptic seizures with ECG using geometric analyses of heart rate variability. / Jeppesen, Jesper; Beniczky, Sándor; Johansen, Peter; Sidenius, Per Christian; Fuglsang-Frederiksen, Anders. Abstract from the 26th Annual Scientific Meeting of the SSRCTS. 2016.

Developing a tool to assess the sustainability of farms with automatic milking systems and grazing. / de Olde, Evelien; Oudshoorn, Frank Willem; Sørensen, Claus Aage Grøn. Abstract from the International Conference on Agricultural Engineering 2016. 2016.

Development of a new Heart valve prosthesis concept for pediatric cardiac surgery. / Jensen, Morten Bjørn; Smerup, Morten Holdgaard; Johansen, Peter. Abstract from the 26th Annual Meeting SSRCTS. 2016.

Development of electrostatic precipitators for small biomass-fired boilers. / Kristensen, Erik Fløjgaard; Kristensen, Jens Kristian; Speiermann, Martin; Linnemann, Niels. Poster presented at 24th European Biomass Conference and Exhibition. 2016.

Doubling the spectrum of time-domain induced polarization: removal of non-linear self-potential drift, harmonic noise and spikes, tapered gating, and uncertainty estimation. / Olsson, Per-Ivar; Fiandaca, Gianluca; Larsen, Jakob Juul; Dahlin, Torleif; Auken, Esben. Abstract from IP2016 - 4th International Workshop on Induced Polarization. 2016.

Dynamic Simulation of Energy Release Rate in the Double Cantilever Beam Specimen using the Absolute Nodal Coordinate Formulation. / Hyldahl, Per Christian; Budzik, Michal Kazimierz; Jensen, Henrik Myhre. Paper presented at Euradh 2016 Adhesion. 2016.

Effect of Free Edges in Double and Single Cantilever Beam Fracture Experiments. / Møberg, Alex; Budzik, Michal Kazimierz; Jensen, Henrik Myhre. Paper presented at Euradh 2016 Adhesion. 2016.

Effect of non-compensated interference of VOC on NH3 measured by IR-PAS and data correction. / Liu, Dezhao; Rong, Li; Chowdhury, Albarune; Adamsen, Anders Peter S.; Feilberg, Anders. Abstract from the International Conference on Agricultural Engineering 2016. 2016.

Effect of pulsation rest phase duration on teat end congestion. / Upton, John; Penry, J.F.; Rasmussen, Morten Dam; Thompson , P.D. ; Reinemann , D.J. Poster session presented at 6th IDF Mastitis Conference. 2016.

Effects of air velocity on heat loss of an artificial pig and the effective temperature development. / Li, Hao; Rong, Li; Zhang, Guoqiang. Abstract from the International Conference on Agricultural Engineering 2016. 2016.

Effects of Stimulus Duration on Gustatory Evoked Potentials. / Rotvel, Camilla; Møller, Stine; Kivisaar, Kätlin; Kjær, Troels Wesenberg; L. Kring, Marianne; Larsen, Ole N; Kidmose, Preben. Poster presented at EUROSENSE 2016 - Seventh European Confernece on Sensory and Consumer Research. 2016.

Effects of teat-end vacuum and mouthpiece chamber vacuum on teat-end swelling. / Penry, J.F.; Upton, John; Rasmussen, Morten Dam; Ohnstad, I.; Thompson , P.D.; Reinemann , D.J. Poster presented at 6th IDF Mastitis Conference. 2016.

Establishing guidelines for valve-in-valve therapy predilatation stent fracturing. / Johansen, Peter; Tang, Mariann; Andersen, Henning Rud; Nielsen-Kudsk, Jens Erik. Abstract from the 26th Annual Meeting SSRCTS. 2016.

Evaluation of intra variability between annotators of weed species in color images. / Dyrmann, Mads; Midtiby, Henrik Skov; Nyholm Jørgensen, Rasmus. Paper presented at the International Conference on Agricultural Engineering 2016. 2016.

Evaluation of turbulence models and mesh for CFD simulation of air distribution in a mechanically ventilated pig house with animal pig models. / Li, Hao; Rong, Li; Zhang, Guoqiang. Paper presented at the International Conference on Agricultural Engineering 2016. 2016.

Extraction and Use of Noise Models from Production-Mode Transient Electromagnetic Data. / Rasmussen, Søren; Skovgaard Nyboe, Nicklas; Larsen, Jakob Juul. Abstract from AGU Fall Meeting 2016. 2016.

Full scale assessment of odor abatement technology by proton-transfer-reaction mass spectrometry. / Feilberg, Anders; Jonassen, Kristoffer; Hansen, Michael Jørgen; Adamsen, Anders Peter S. Abstract from the International Conference on Agricultural Engineering 2016. 2016.

Geometric comparison of aortic root repair procedures, an in vivo experiment. / Bechsgaard, Tommy Kragh; Lindskow, Thomas; Lading, Troels ; Rasmussen, Jonas; Røpcke, Diana Mathilde; Tjørnild, Marcell Juan; Nygaard, Hans; Johansen, Peter; Nielsen, Sten Lyager. Abstract from the 26th Annual Meeting SSRCTS. 2016.

Grass and agricultural byproducts for energy : an optimized anaerobic digestion technology. / Feng, Lu; Møller, Henrik Bjarne; Grima Guixe, Pau; Kristensen, Erik Fløjgaard. Paper presented at the International Conference on Agricultural Engineering 2016. 2016.

Impact of Field Acidification and Application Methods on Ammonia Emissions, Yield and NItrogen Effeciency of Organic Liquid Manures. / Nyord, Tavs. Poster. 2016.

In vivo comparison of different valve-sparing aortic root repair technique. David versus Yacoub with and without subvalvular annuloplasty. / Benhassen, Leila Louise; Røpcke, Diana Mathilde; Lading, Troels ; Lindskow, Thomas; Bechsgaard, Tommy Kragh; Nielsen, Sten Lyager. Abstract. 2016.

Joint Source-Channel Optimization of Vector Quantization with Polar Codes. / Mohammadi, Mohammad Sadegh; Dutkiewicz, Eryk; Zhang, Qi. Paper presented at the IEEE Vehicular Technology Conference 2016. 2016.

Microscale dynamics of H2, CO2 and pH during H2 supply to biogas reactors. / Maegaard, Karen; Garcia-Robledo, Emilio; Ottosen, Lars Ditlev Mørck; Voigt, Niels Vinther; Kofoed, Michael; Revsbech, Niels Peter. Poster presented at ISME 16 - 16th International Symposium on Microbial Ecology. 2016.

More energy and reduction of GHG gases by optimization of the biogas technology : a case study. / Møller, Henrik Bjarne; Hernandez, Veronica Moset; J. Nielsen, Karl. Paper presented at the International Conference on Agricultural Engineering 2016. 2016.

Multi-modal Obstacle Detection and Evaluation of Occupancy Grid Mapping in Agriculture. / Hansen, Mikkel Kragh; Christiansen, Peter; Korthals, Timo; Jungeblut, Thorsten; Karstoft, Henrik; Nyholm Jørgensen, Rasmus. Paper presented at the International Conference on Agricultural Engineering 2016. 2016.

Networks versus Storage in a Highly Renewable European Electricity System : A Continuous Parameter Sweep. / Schlachtberger, David; Brown, Tom; Schramm, Stefan; Greiner, Martin. Paper presented at the 11th Conference on Sustainable Development of Energy, Water and Environment Systems. 2016.

New insight on span selection for Chinese solar greenhouses using CFD analyses. / Tong, Guohong; Davis, Christopher; Zhang, Guoqiang. Paper presented at the International Conference on Agricultural Engineering 2016. 2016.

Numerical study of airflow characteristics in a Danish pig room with partial pit ventilation system. / Zong, Chao; Zhang, Guoqiang. Paper presented at the International Conference on Agricultural Engineering 2016. 2016.

Numerical study on a simplification approach to simulate slatted floor in an animal building. / Zong, Chao; Zhang, Guoqiang; Teng, Guanghui. Abstract from the International Conference on Agricultural Engineering 2016. 2016.

Numerical study on the convective heat transfer of fattening pigs in mechanical ventilated pig house. / Li, Hao; Rong, Li; Zhang, Guoqiang. Paper presented at International Conference on Agricultural Engineering 2016. 2016.

Olfactometric and chemical analysis for further development of environmental technologies. / Hansen, Michael Jørgen; Feilberg, Anders; E. N. Jonassen, Kristoffer ; Guldberg, Lise; Løkke, Mette Marie; Adamsen, Anders Peter S. Abstract from the International Conference on Agricultural Engineering 2016. 2016.

Optical Isolators for Photonic Integrated Circuits. / Heck, Martijn. Abstract from ECIO 2016. 2016.

Optimal design of precision air supply in a natural ventilated cattle barn using CFD method. / Wang, Xiaoshuai; Zhang, Guoqiang. Abstract from the International Conference on Agricultural Engineering 2016. 2016.

Optimization of an in vitro model for Heart valve research. / Khalipina, Diana; Johansen, Peter. Poster presented at 26th Annual Meeting SSRCTS. 2016.

Optimization of bio-methane production from briquetted wheat straw by direct injection of KOH. / Feng, Lu; Hernandez, Veronica Moset; Møller, Henrik Bjarne. Poster presented at 2nd NJF - Agromek - EurAgEng joint seminar. 2016.

Optimization of mechanical heart valve cavitation detection. / Krishna, S K; Weng, P; Johansen, Peter. Abstract from the 26th Annual Meeting SSRCTS. 2016.

Personal Sound Zones : The significance of loudspeaker driver nonlinear distortion. / Ma, Xiaohui; J. Hegarty, Patrick; Abildgaard Pedersen, Jan; Johansen, Lars G.; Larsen, Jakob Juul. Paper presented at the 2016 AES International Conference on Sound Field Control. 2016.

Pixel-wise classification of weeds and crops in images by using a Fully Convolutional neural network. / Dyrmann, M.; Mortensen, Anders Krogh; Midtiby, Henrik Skov; Nyholm Jørgensen, Rasmus. Paper presented at the International Conference on Agricultural Engineering 2016. 2016.

Pre-treatment of lignocellulosic biomass : a Danish case study. / Møller, Henrik Bjarne; Hernandez, Veronica Moset; Feng, Lu; Wahid, Radziah. Paper presented at Biogas Science 2016. 2016.

Precision ventilation in farm animal housing. / Zhang, Guoqiang; Zong, Chao; Rong, Li. Paper presented at the 1st Asian Conference on Precision Livestock Farming. 2016.

Present Status and Future Needs of Biogas Technology in Bangladesh. / Monjurul Alam, Md.; Saha, Chayan Kumer; Rahman, Muhammad Anisur; Møller, Henrik Bjarne; Rafiqul Islam, Md.; Jahiruddin, M. Poster presented at International Conference on Agricultural Engineering 2016. 2016.

Real time back projection onto prerecorded DHM surface of UAV recorded images with RTK GPS and IMU. / Laursen, Morten Stigaard; Larsen, Rene; Jensen, Kjeld; Nyholm Jørgensen, Rasmus. Paper presented at the International Conference on Agricultural Engineering 2016. 2016.

Reducing variability of workforce as a tool to improve plan reliability. / Wandahl, Søren; Yicheng, S.; Zygmunt, K. J. Poster presented at Modern Building Materials, Structures and Techniques. 2016.

Response Surface Method for modelling air distribution in a pig room to improve air inlet design. / Li, Hao; Rong, Li; Zong, Chao; Zhang, Guoqiang. Abstract from the International Conference on Agricultural Engineering 2016. 2016.

Review on mechanism of natural ventilation in livestock buildings past studies future challenges. / Rong, Li; Bjerg, B.; Bartzanas, Thomas; Zhang, Guoqiang. Abstract from the International Conference on Agricultural Engineering 2016. 2016.

Sector Coupling in a Highly Renewable European Energy System. / Brown, Tom; Schlachtberger, David; Kies, Alexander; Greiner, Martin. Paper presented at 15th Wind Integration Workshop. 2016.

Silicon Photonics for millimeter-Wave Generation: an Energy-Efficiency Analysis. / Mohammadhosseini, Hakimeh; Heck, Martijn. Abstract from ECIO 2016. 2016.

Smart indoor climate control in precision livestock farming. / Zhang, Guoqiang; Bjerg, Bjarne; Wang, Xiaoshuai. Paper presented at 1st Asian Conference on Precision Livestock Farming. 2016.

Stable Mode II Fracture Experiment for Adhesive Joints. / Budzik, Michal Kazimierz; Jumel, Julien. Paper presented at Euradh 2016 Adhesion. 2016.

Storage and pretreatment of grass for from extensive lowland areas used in a biogas plant. / Kristensen, Erik Fløjgaard; Feng, Lu; Møller, Henrik Bjarne. Paper presented at the International Conference on Agricultural Engineering 2016. 2016.

The effect of air velocity on heat stress at increased air temperature. / Bjerg, B.; Wang, Xiaoshuai; Zhang, Guoqiang. Paper presented at the International Conference on Agricultural Engineering 2016. 2016.

The effect of small temperature differences in mesophilic sludge-based digesters. / Nielsen, Maja; Holst-Fischer, Christian ; Malmgren-Hansen, Bjørn; Kofoed, Michael Vedel Wegener ; Kragelund, Caroline; Møller, Henrik Bjarne; Ottosen, Lars Ditlev Mørck. Abstract from the International Conference on Agricultural Engineering 2016. 2016.

The effect of small temperature differences on biogas yield in sludge-based biogas digesters. / Nielsen, Maja; Holst-Fischer, Christian ; Malmgren-Hansen, Bjørn; Kragelund, Caroline; Møller, Henrik Bjarne; Ottosen, Lars Ditlev Mørck. Poster presented at IWA Microbial Ecology in Water Engineering & Biofilms. 2016.

The effects of air speed and pump on-time on dynamic performance of evaporative cooling pad. / Rong, Li; Zhang, Guoqiang; Pedersen, P.; Ladegaard Jensen, Thomas; Morsing, Svend. Abstract from the International Conference on Agricultural Engineering 2016. 2016.

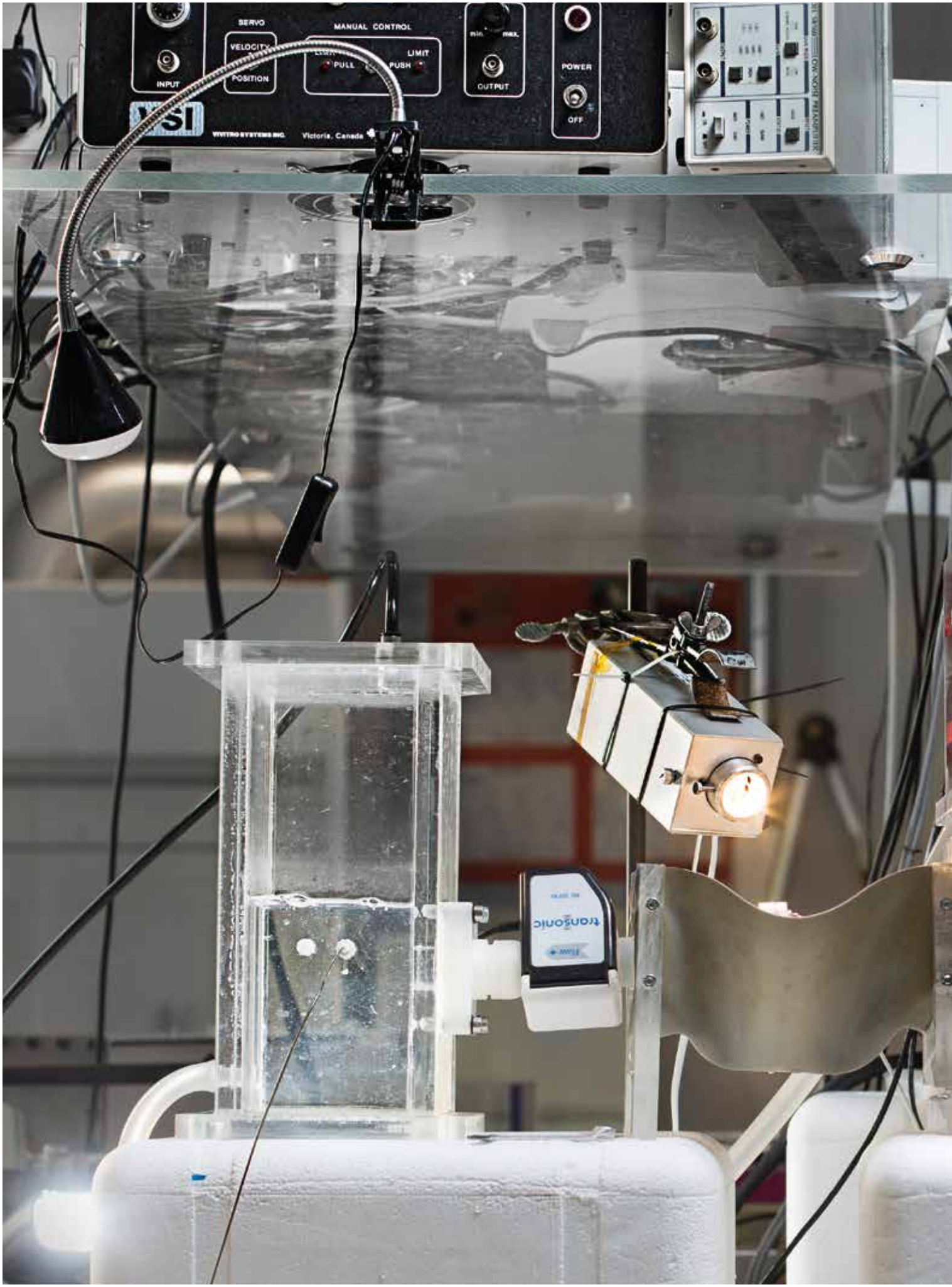
Theory of ion and water flow through charged nanotubes. / Biesheuvel, P. M.; Catalano, Jacopo. Abstract from the 67th Annual Meeting of the International Society of Electrochemistry. 2016.

Towards Autonomous Plant Production using Fully Convolutional Neural Networks. / Christiansen, Peter; Sørensen, René; Skovsen, Søren ; Jæger, Claes D. ; Nyholm Jørgensen, Rasmus; Karstoft, Henrik; Steen, Kim Arild. Paper presented at the International Conference on Agricultural Engineering 2016. 2016.

Towards Data-Driven Precision Agriculture using Open Data and Open Source Software. / Jeppesen, Jacob Høxbroe; Jacobsen, Rune Hylsberg; Nyholm Jørgensen, Rasmus; Toftegaard, Thomas Skjødeberg. Paper presented at the International Conference on Agricultural Engineering 2016. 2016.

Towards UAV contour flight over agricultural fields using RTK-GNSS and a Digital Elevation Model. / Jensen, Kjeld; Laursen, Morten Stigaard; M. Neerup, Mathias; Skriver, Martin; Larsen, Rene; Nyholm Jørgensen, Rasmus. Paper presented at the International Conference on Agricultural Engineering 2016. 2016.

When should the cluster be detached for cows? : A review of the literature. / Rasmussen, Morten Dam; Dzidic, A.; Tancin, V.; Ginsberg, R.; Bruckmaier, R M; Reinemann, D.J. Poster presented at 6th IDF Mastitis Conference. 2016.



Katrinebjerg Campus, Aarhus

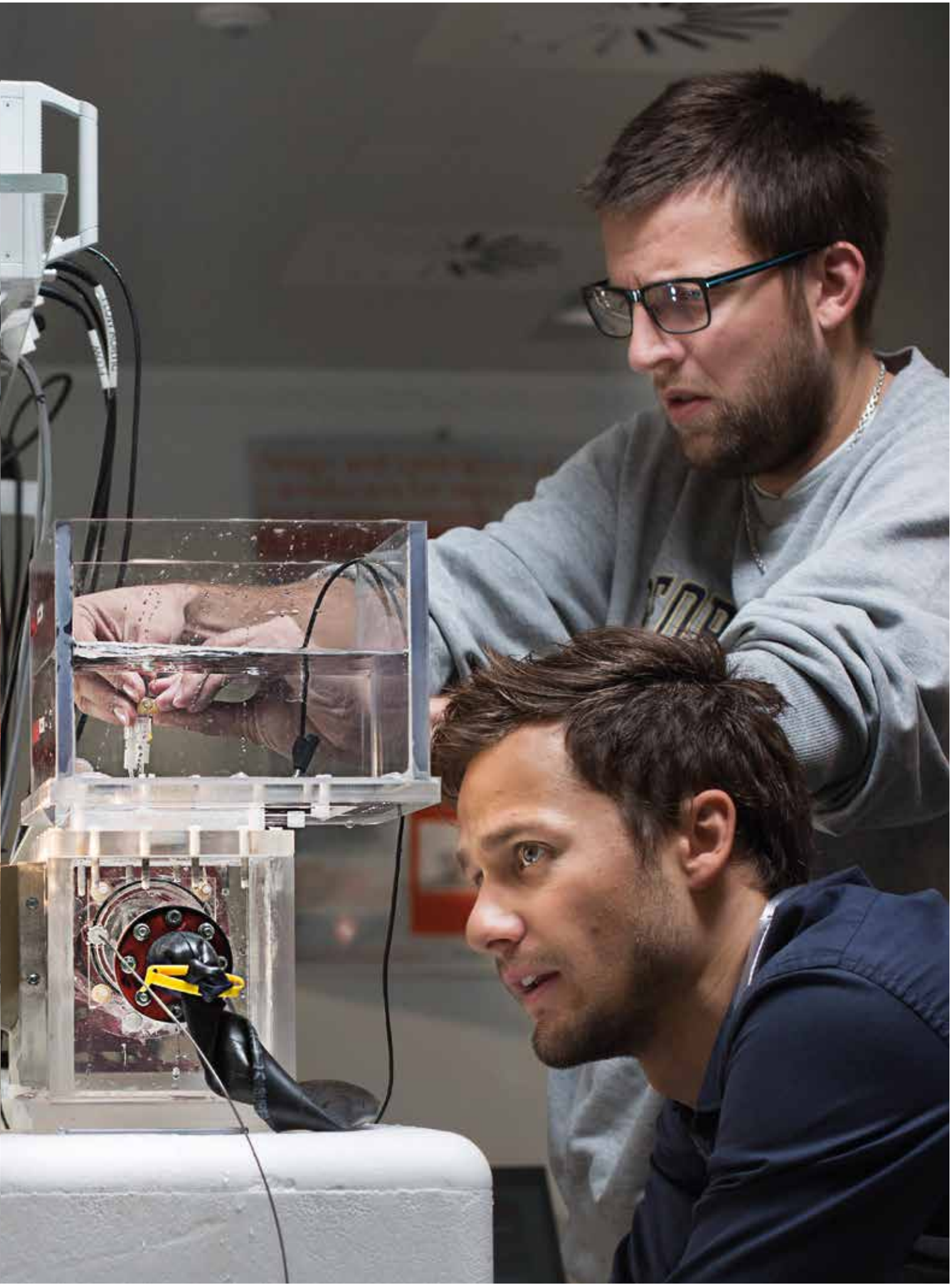


Photo: Lars Kruse

PATENTS

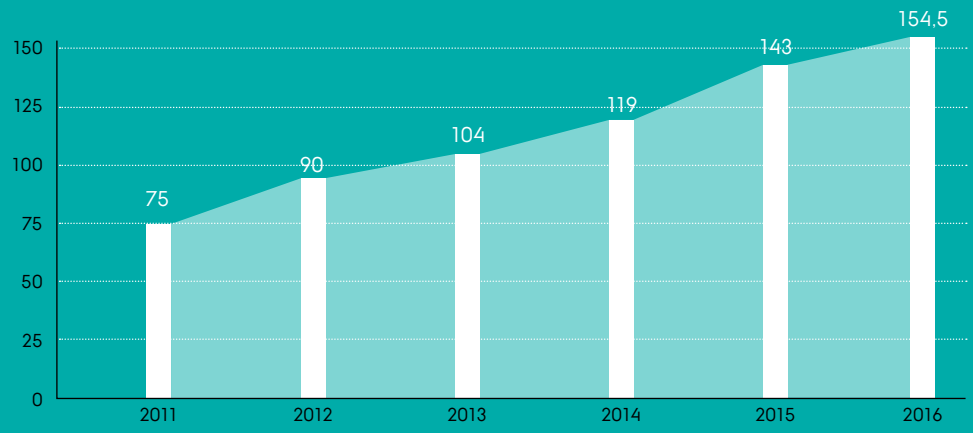
2016

A Method and Apparatus for Producing Biofuel in an Oscillating Flow Production Line under Supercritical Fluid Conditions, Johannsen, I., Adamsen, A. P. S., Kilsgaard, B. S. & Milkevych, V., January 2016.

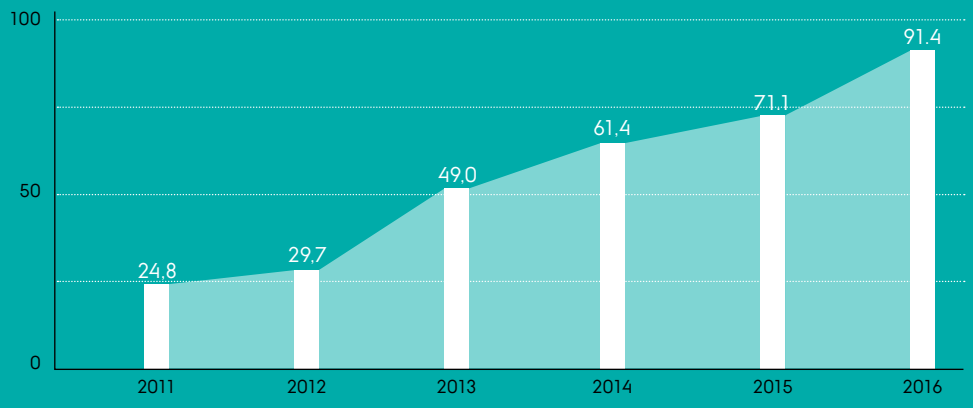
An active electrode having a closed-loop unit-gain amplifier with chopper modulation, Kidmose, P., Zhou, X., Kilsgaard, S. & Li, Q., June 2016.

KEY FIGURES

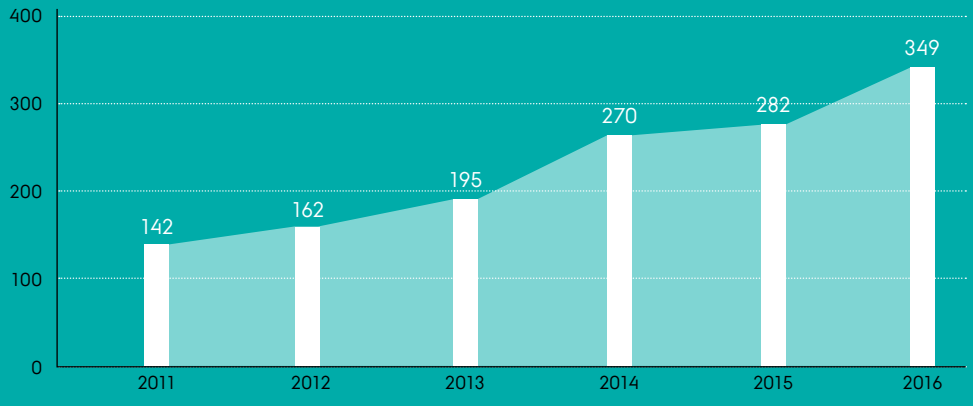
TOTAL ENG TURNOVER (M DKK)
Based on annual FC3 budget



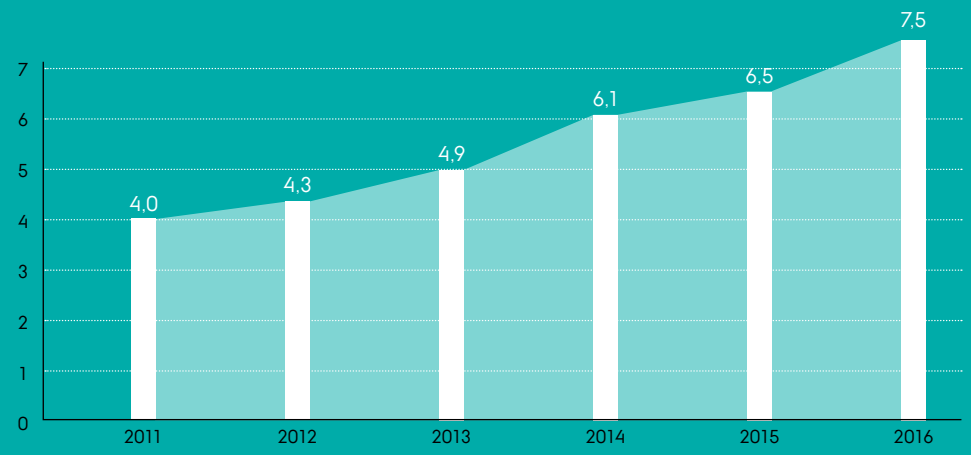
EXTERNAL FUNDING TOTAL (M DKK)
Based on annual FC3 budget



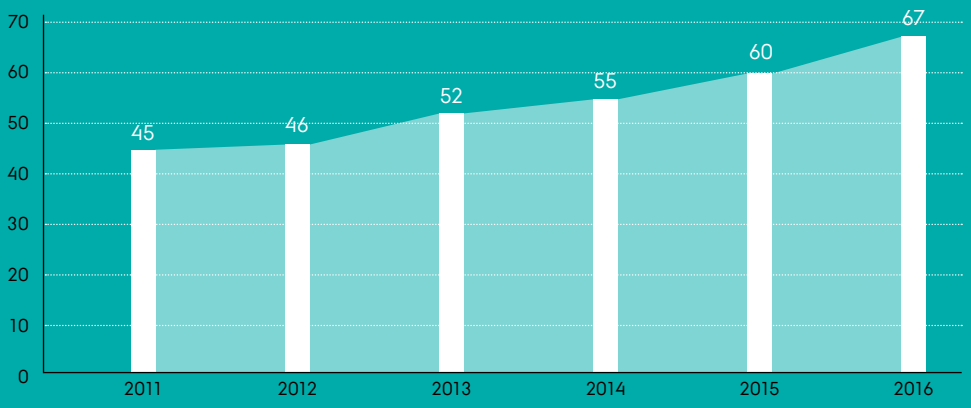
PEER REVIEWED PUBLICATIONS



PEER REVIEWED PUBLICATIONS PER VIP

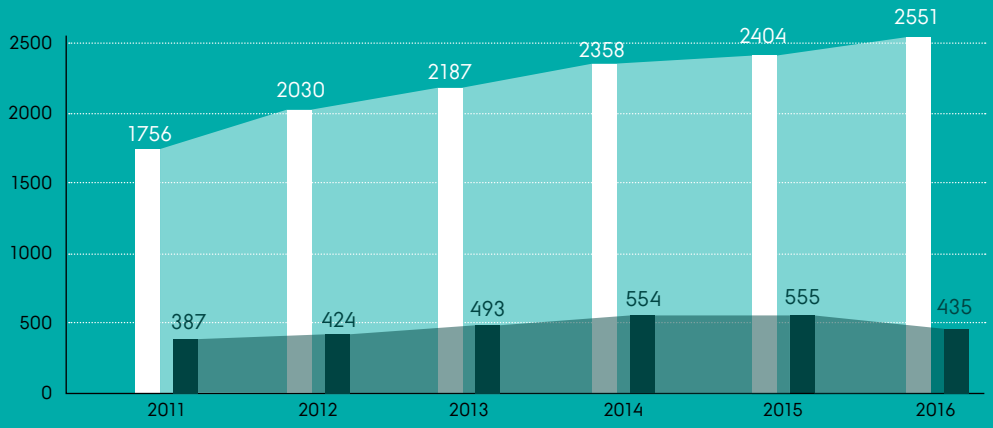


ENGINEERING PHD STUDENTS



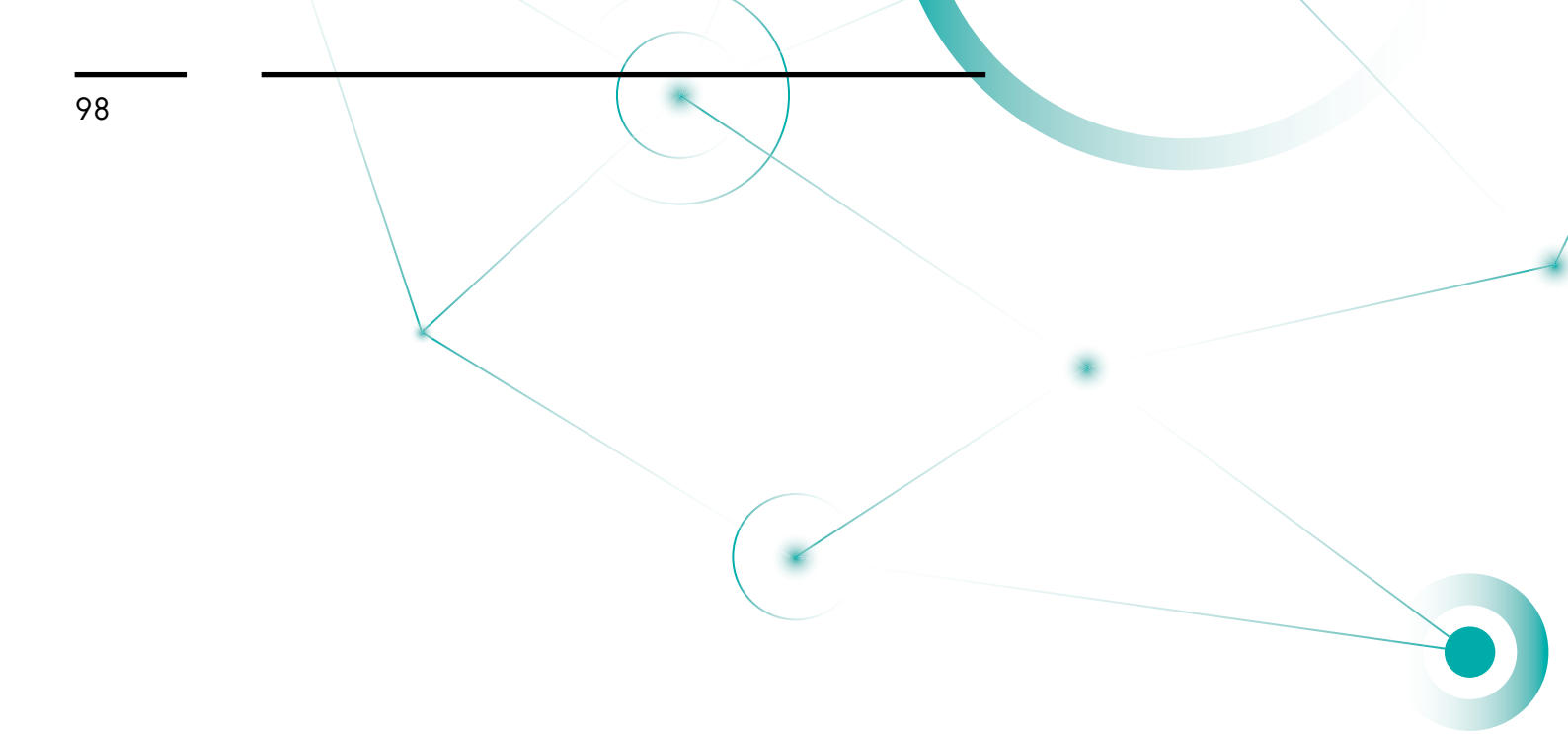
ENROLLED ENGINEERING STUDENTS

BACHELOR
MASTER



Hangøvej Campus, Aarhus

Photo: Lars Kruse



Profile 2017 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.

DEPARTMENT OF ENGINEERING, PROFILE 2017

Produced by:
Department of Engineering, April 2017

Editors:
Kim Harel, Jesper Bruun, Heidi Søndergaard, Thomas Skjødeberg Toftegaard, Mette Stig Hansen

Design & layout:
Astrid Friis Reitzel, AU Research Support and External Relations

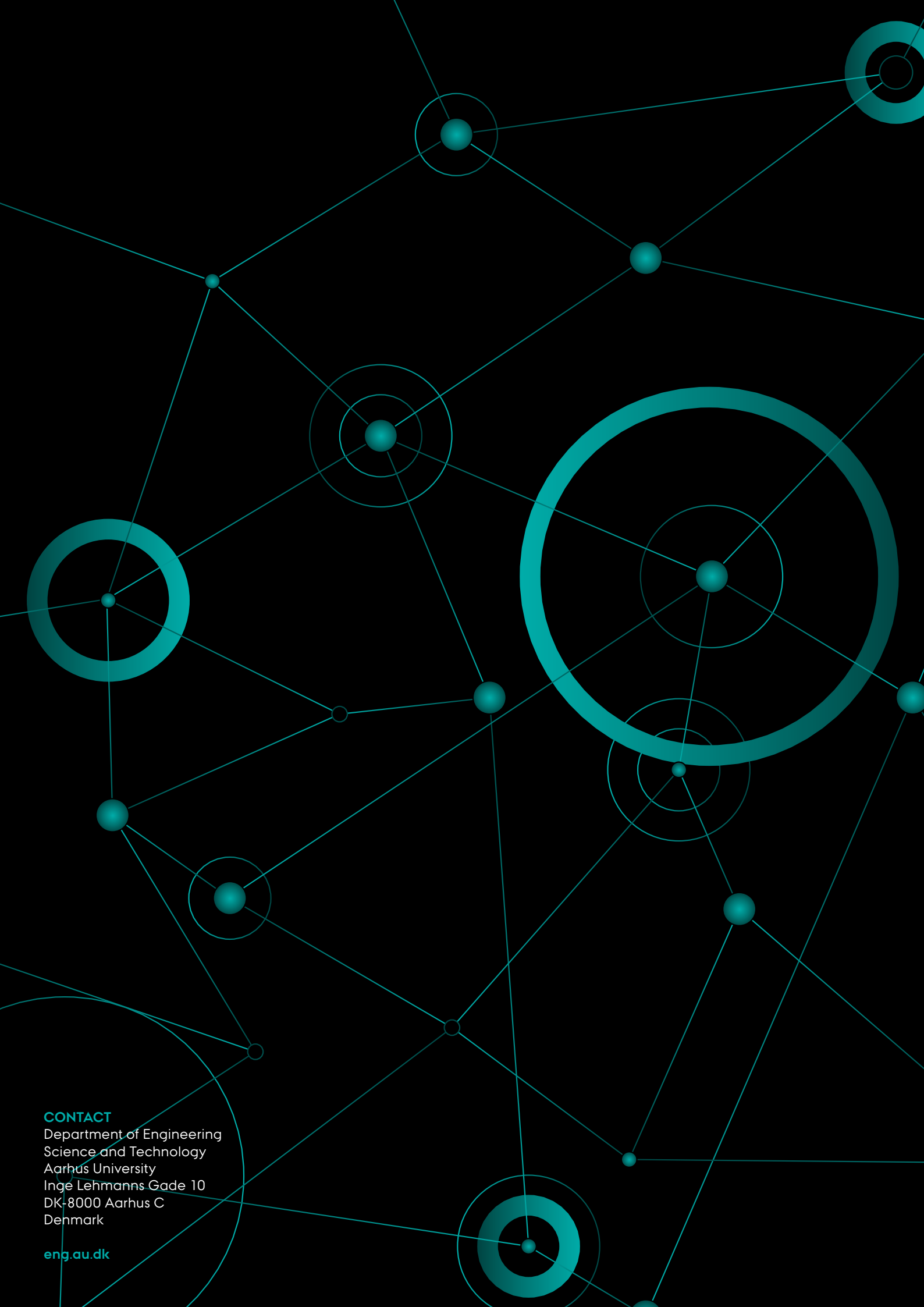
Photos:
Lars Kruse, Anders Trærup, Jesper Rais, Melissa Bach Yilderim, AU Research Support and External Relations
Colourbox

Print:
Vahle+Nikolaisen

Edition:
1,000 psc

ISBN: 978-87-92829-55-9

eng.au.dk/profile2017



CONTACT
Department of Engineering
Science and Technology
Aarhus University
Inge Lehmanns Gade 10
DK-8000 Aarhus C
Denmark

eng.au.dk