Technical University of Denmark

Annual Report **2014**

DTU Chemical Engineering
Department of Chemical and Biochemical Engineering

Annual Report 2014
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VISION

DTU Chemical Engineering:

- Acknowledged as a world-leading chemical engineering department.
- An attractive partner for university departments and research-based industry.
- Helps to retain, develop and attract knowledge-based national working places, including companies with affiliates abroad.
- Supports development of sustainable solutions in the fields of chemistry, biotechnology, food, pharma and energy through research and scientific advice.
- Attractive as a place to work for ambitious and technology-passionate staff members.

ANNUAL REVIEW

Head of Department

Kim Dam-Johansen
Professor, Head of Department

REACHING NEW HEIGHTS FROM DEEPER INSIGHTS

2014 has been a good year for us. Our study programmes continue to cover the core fields of chemical and biochemical engineering. Our research continues to be of a high international standard, ambitious, ground-breaking and applicable. And our innovation activities, such as our many partnerships with universities and businesses, continue to create, secure and develop jobs in Denmark and abroad.

Turning the microscope on ourselves

From an organizational perspective, one of the most significant events of 2014 was the international research evaluation by the DTU Department of Chemical and Biochemical Engineering Review Panel in the beginning of the year. The evaluation not only affirmed our position as a department possessing cutting-edge theoretical and laboratory capabilities to address industrially relevant problems, it also set the course for the journey that has very much characterized 2014. The evaluation forced us to turn the microscope on ourselves—and with this newfound insight we have been able discover new ways to become even more focused and efficient in our research.

One of the results of the evaluation has been our decision to merge two of our research centres in order to create a stronger, unified CAPEC-PROCESS centre headed by Professor Krist Gernaey. Furthermore, we have moved many of our activities from Campus Risø to Campus Lyngby in order to reach our goal of closer integration.

Internationalization of our education

In relation to education one of our goals is to secure a constant flow of talented international chemical engineering students. This year, we have succeeded in recruiting students

from all over the world for our MSc programmes. Furthermore, during this year's Summer University—where 100 students visited our Department from the US, Europe and China to work on experimental process technology—sustainability was at the heart of the programme. In fact, 16 students from our MSc programme in Beijing participated in the DTU Grøn Dyst (Green Challenge) competition where one of the projects won an impressive second place.

Innovation comes from the best mix of expertise

Another one of our key goals is to continue to develop our research and innovation profile through partnerships with companies and other universities. This not only improves our research by connecting the most innovative minds of the world, it also secures the relevance of our research findings. In this regard, 2014 produced some exciting new partnerships. One of them is an agreement with the Institute of Process Engineering (IPE) as part of the Chinese Academy of Sciences. In the coming years, up to six Chinese students from IPE per year will be enrolled as PhD students at our Department.

2015: This we look forward to

In 2015 and in the years to come, we will continue to develop our research considering the on-going development of our basic core disciplines as well as the needs of society and industry. In this connection, we look forward to re-developing a new, high-profile Bachelor of Engineering programme in chemical and biochemical engineering. And we look forward to renewing our large-scale experimental courses to include even more activities related to particle technology. In 2015 and onward, we will also continue to organize both national and international conferences. In this regard, we are looking forward to hosting the PSE2015/ESCAPE25 Conference, the Thermodynamics 2015 Conference, and the Nordic Flame Days 2015.

The building blocks of success: A thanks to the people who made it happen

Our success of 2014 did not appear out of nothing. I would like to express my appreciation to the hard-working scientific, technical and administrative staff at our Department. I would also like to thank our many dedicated PhDs—and of course, our many dedicated partners from Denmark and abroad. Thanks to them, our Department is stronger than ever and ready to take on new endeavours in 2015.

This Annual Report offers a glimpse into our many exciting projects in 2014, which I hope you will enjoy reading about in the following pages.

Kim Dam-Johansen
Professor, Head of Department


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HIGHLIGHTS 2014



① Assistant Professor Philip Fosbøl gives the Review Panel a tour.
② Faculty meeting on future development.
③ The new state-of-the-art PVT apparatus arrives

HIGHLIGHTS **2014**

JANUARY

PROFESSOR RAFIQUL GANI STARTS HIS EFCE PRESIDENCY

1 January

In 2013, Professor Rafiqul Gani was elected President of the European Federation of Chemical Engineering (EFCE). In January 2014, he commenced his presidency which will run for two years.

NEW PROJECT: SEAWEED BIOREFINERY IN GHANA

1 January

SeaBioGha will establish seaweed cultivation along Ghana's coastline, and establish relevant technology, develop local know-how and business opportunities for seaweed cultivation and processing of seaweed products in Ghana. The project is run in collaboration with DANIDA and is headed by Professor Anne Meyer, Head of BioEng and Senior Researcher Anders Thygesen.

JESPER HOLCK RECEIVES ARLA AWARD FOR YOUNG SCIENTISTS

January

The Arla Award for Young Scientists honours the most promising talent based on scientific as well as commercial perspectives, and includes funding of one year of postdoctoral research. Jesper Holck, Researcher from BioEng received the award on the basis of his work with human milk oligosaccharides.

RESEARCH EVALUATION OF THE DEPARTMENT ①

26 – 29 January

The Review Panel concluded that the DTU Chemical and Biochemical Engineering is a well-organized department with a clear vision, cutting-edge theoretical and laboratory capabilities to address industrially relevant problems and with several research groups with internationally leading positions. The Review Panel consisted of representatives from Auburn University, University of British Columbia, Chr. Hansen A/S, Åbo Akademi, Aalto University and the Technical University of Dortmund.

FACULTY MEETING ON FUTURE DEVELOPMENT ②

30 –31 January

The Faculty met for a one and a half day seminar. The primary focus was study programmes, teaching and innovation.

FEBRUARY

NEW PROJECT: HYDROGEN-ASSISTED CATALYTIC BIOMASS PYROLYSIS FOR GREEN FUELS

1 February

H2CAP is a research project in the CHEC Research Centre which focuses on the conversion of biomass to liquid fuels in order to be able to integrate it into the current transportation infrastructure. The projects utilizes second-generation biomass like straw and wood and aims to develop an integrated process of high-pressure pyrolysis of biomass with catalytic hydrotreating before condensation of the liquid product.

OTTO MØNSTED PROFESSOR, MASAO DOI GIVES LECTURES ON SOFT MATTER PHYSICS

2 February – 12 May

The purpose of the lecture series was to discuss general principles in thermodynamics and irreversible thermodynamics which are useful in understanding the complex behaviour of soft matter. The lectures were given during the spring semester of 2014.

④ Assistant Professor Jakob Munkholt Christensen gives a presentation at the CHEC Annual Day.
⑤ Head of Department, Professor Kim Dam-Johansen shows the delegation from VGB Powertech around at the Department

NEW STATE-OF-THE-ART PVT APPARATUS ③

3 February

A state-of-the-art PVT (pressure, volume and temperature) apparatus arrived at AT CERE in February. The apparatus is purchased for the NextOil project funded by the Danish National Advanced Technology Foundation (Højteknologifonden). The main purpose of the apparatus is to perform PVT study of reservoir fluids especially at high pressure and high temperature (HP/HT) conditions.

MEETING ON DEVELOPMENT GOALS AND MEASURES

3 February

Two sessions about the UMV (development goals and measures) strategy were held, one at Risø Campus and subsequently one at Lyngby Campus. The purpose was to inform about the overall strategy process at DTU and the Department, and to gather input and ideas. Research-based education and innovation, future research focus and development of our human resources was also discussed.

MARCH

CHEC ANNUAL DAY ④

10 March

CHEC's Annual Day 2014 was a tremendous success with a total number of 90 participants. Key presentations were given by senior professors and scientists at CHEC. The day concluded with a reception and poster presentations at DTU Chemical Engineering.

VISIT FROM DI'S EDUCATION AND RESEARCH COMMITTEE

11 March

The Confederation of Danish Industry's (DI) Education and Research Committee visited DTU to hear about the projects at DTU, and to see our premises. Leading representatives from, among others, DONG Energy, Haldor Topsøe, Carlsberg and Lundbeck were present. The Committee also visited DTU Chemical Engineering together with DTU's Executive Board. Head of Department Professor Kim Dam-Johansen gave a lecture and a tour of the Pilot Plant.

VISIT FROM THE EUROPEAN TECHNICAL ASSOCIATION, VGB POWERTECH ⑤

20 March

DTU Chemical Engineering hosted the 83rd meeting of the VGB PowerTech Scientific Advisory Board of which Head of Department Professor Kim Dam-Johansen is a member. The delegation counted 20 members from Europe, and presentations were given by, among others, COWI, DONG Energy, HOFOR and DTU Chemical Engineering.

PETROLEUM ENGINEERING EDUCATION EVENT

26 March

The DTU SPE Student Chapter, together with Associate Professor Shapiro, organized an event to promote the Petroleum Engineering programme to DTU bachelor students. Around 75 students participated, and SPE Copenhagen Section chairman Hans Horikx introduced the students to the science involved in petroleum engineering.



⑥ Professor Kim Dam-Johansen with the official Danish delegation. Photo by Lars Christensen.
⑦ Associate Professor Søren Kiil receives the Danish Polymer Prize 2014. Photo by Tom Jersø/ATV.
⑧ President of DTU Anders Bjarklev, presents President and CEO of Haldor Topsøe A/S, Bjerne S. Clausen with an honorary doctorate.

APRIL

GRANT FOR TECHNICAL RESSEARCH

7 April

As Head of DPC, Professor Ole Hassager has been granted a donation of DKK 7.5 million by the Aage og Johanne Louis-Hansen's Foundation over the next five years. The centre will receive DKK 1.5 million a year.

PROFESSOR KIM DAM-JOHANSEN INVITED TO RESEARCH LUNCH IN CHINA ⑥

25 April

HRM Queen Margrethe II hosted a research lunch in Beijing for 9 selected Chinese and Danish researchers considered pioneers in establishing early connections between Denmark and China—one of these researchers was our Head of Department, Kim Dam-Johansen. Among the participants were the Minister for Higher Education and Science, Sofie Carsten Nielsen, and the Minister for Foreign Affairs, Martin Lidegaard. During the lunch, the researchers were asked to give a short speech about the strengths and weaknesses in Danish-Chinese research collaboration.
The research lunch was part of a visit to China by HRM Queen Margrethe II and HRH Prince Consort Henrik, four Danish ministers and representatives of more than 100 Danish companies to strengthen the cultural bonds and trade between the Denmark and China and to increase focus on sustainability. The Queen's visit also included a ground-breaking ceremony, marking the new building for the Sino-Danish Center for Education and Research (SDC).

JOINT PHD SUPERVISION AGREEMENT WITH INSTITUTE OF PROCESS ENGINEERING

April

An agreement was signed concerning shared PhD students between the Department of Chemical Engineering and the Institute of Process Engineering (IPE), part of the Chinese Academy of Sciences. The agreement is a further development of the strategic cooperation between DTU Chemical Engineering and IPE regarding the MSc programme as part of the Sino-Danish Center for Education and Research (SDC).

MAY

SØREN KIIL RECIEVES THE DANISH POLYMER PRIZE ⑦

6 May

Associate Professor Søren Kiil was awarded the Danish Polymer Prize—Elastyrenprisen 2014, for having contributed with significant, new research-based knowledge about polymers in coating, and for his ability to link research findings with industrial application.

BJERNE S. CLAUSEN NAMED HONORARY DOCTOR ⑧

9 May

Bjerne S. Clausen, President and CEO of Haldor Topsøe and long-time member of the Department's Advisory Board, was named Honorary Doctor at the DTU annual Commemmoration Day.

RESEARCH DAY

27 May

The purpose of the Research Day was to increase internal collaboration between research centres through different activities such as scientific speed-dating and presentations.

⑨ Professor Costas G. Panayiotou attends poster session at the CERE Discussion Meeting.
⑩ Professor Georgios Kontogeorgis gives a speech about his ambitions as new Head of CERE.
⑪ Managing Director of BIOPRO, Jesper Bryde-Jacobsen awards the winning team of the World Talent Campus Challenge 2014.

JUNE

NEW PROJECT: SUSTAINABLE ANIMAL FEED PRODUCTION

10 June

In the Efpro^2 project funded by the Innovation Fund Denmark, researchers from CAPEC-PROCESS will operate a pilot-scale continuous fermentation process for the production of single cell protein from natural gas. The protein will be designed specifically for pig feed and will provide a more sustainable alternative to soya and fishmeal.

MERGER BETWEEN CAPEC AND PROCESS

12 June

The merger between the two centres Computer Aided Process Engineering Center (CAPEC) and the Center for Process Engineering and Technology (PROCESS) was announced at the CAPEC-PROCESS Annual Meeting where no less than 92 attendees from universities and industry came to network and exchange the latest research results. Head of the new, joined CAPEC-PROCESS is Professor Krist Gernaey, professor in industrial fermentation technology at the Department. The focus of his work is on modelling, development and optimization of industrial fermentation, biocatalysis, pharmaceutical and food production processes.

VISIT BY GUEST PROFESSOR COSTAS G. PANAYIOTOU ⑨

15 June – 15 September

Professor Panayiotou from Aristotle University of Thessaloniki visited the Department to bring a different perspective on potential areas of collaboration between the two centres, CERE and CAPEC-PROCESS, but also between DTU and Aristotle University. During his stay, he gave the departmental seminar 'From Metabolic Pathways to Tissue Engineering: A Journey with Molecular Thermodynamics'.

SCIENCE IN THE CITY FESTIVAL

21 – 25 June

Together with DTU Environment, the Department's Centre for Ecosystems and Environmental Sustainability (ECO) participated in Science in the City which took place at Carlsberg City in Copenhagen. Here, they enriched the curious visitors with knowledge about household waste, energy generation (biogas), biological upgrading of methane and recycling of residuals.

CERE ANNUAL MEETING

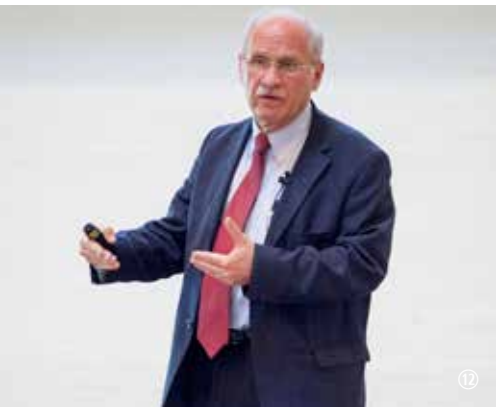
25 –27 June

The CERE Annual Discussion Meeting 2014 was held in June, and more than 100 participants from different countries—including members representing more than 30 different companies—met to network and share the latest research results.

SDC STUDENTS WIN 2ND PLACE IN GREEN CHALLENGE COMPETITION

27 June

By turning wastewater from dairy production into reusable water, four students; Henrik Teglborg, Yujue Wang, Liyan Zhao & Gongzhe Chen, from our MSc programme at the Sino-Danish Center for Education and Research (SDC) in Beijing, won 2nd place in the DTU Grøn Dyst (Green Challenge). The prizes are given to the greenest, most visionary and achievable projects. The competition was part of the in all 16 SDC students' 7-week Summer University courses at the Department.



⑫ Professor Ignacio E. Grossman gives the inaugural lecture at the first CAPEC-PROCESS Annual Lecture.
⑬ Science students learn about polymers. Photo by Lotte Grandorf.
⑭ Associate Professor Ulrich Krühne shows Austrian delegation the pilot facilities.

JULY

NEW HEAD OF CERE: PROFESSOR GEORGIOS KONTOGEORGIS ⑩

1 July

Professor Georgios Kontogeorgis, Head of AT CERE, was announced Head of the collaborative research centre CERE — Center for Energy Resources Engineering. Professor Kontogeorgis works in the field of thermodynamics, colloid and surface chemistry, chemical product design and CO_2 capture.

SUMMER UNIVERSITY

4 July – 1 August

Once again the Department opened its doors to Summer University students from all around the world. 80 American students and 18 European and Chinese students participated in the courses where they were challenged with designing and operating pilot plants.

MICHAEL L. MICHELSEN RECIEVES EFCE AWARD

6-9 July

Professor Michael L. Michelsen was awarded the 2014 EFCE Distinguished Lecture in Thermodynamics and Transport Properties as a recognition of his long and outstanding career in applied thermodynamics.

STRONG REPRESENTATION AT THE 8TH INTERNATIONAL FOCAPD CONFERENCE

17 July

Professor Rafiqul Gani gave a plenary lecture, and Associate Professor Jakob Huusom gave a key note lecture at the 8th international conference on the Foundations of Computer-Aided Process Design (FOCAPD 2014) in Washington. Moreover, PhD student Deneesh K. Babi, was awarded for the best contribution to Innovation for Sustainability at the Interfaces of Process & Product Design.

AUGUST

VISITING PROFESSORS FROM UNIVERSIDAD AUTONOMA METROPOLITANA IN MEXICO

1 August

For one year, CAPEC-PROCESS has the pleasure of hosting Professor Teresa Lopez-Arenas and Professor Mauricio Sales-Cruz from the Department of Process and Technology at Universidad Autonoma Metropolitana in Mexico. The two researchers are dedicating their sabbatical year to work closely with Professor Rafiqul Gani on projects related to the modelling and simulation of Biorefineries and computer aided process modelling.

JAKOB KJØBSTED HUUSOM NAMED ASSOCIATE PROFESSOR

1 August

Jakob Kjøbsted Huusom commenced his PhD at DTU Chemical Engineering in 2005. This year, he became associate professor at the Department. Jakob Huusom conducts research in the development of systems engineering in the area of dynamic modelling, simulation and control with the focus on general methods and tools for the chemical and biochemical process industry.

ANDERS EGEDE DAUGAARD NAMED ASSOCIATE PROFESSOR

1 August

Anders Daugaard started as a PhD student at the Department in 2006 and in 2014 he became associate professor. Daugaard's research area is focused on the preparation of functional polymer materials based on macromolecular synthesis for applications such as polymer surfaces or interfaces with tailored surface properties or improved interfacial interaction in nanocomposites.

⑮ PhD student Rune Nordvang teaches enzyme technology to the Hempel-DTU Prize winners. Photo by Mathias Davidsen.
⑯ Associate Professor Flemming Frandsen receives the Fuel Quality Hero Award.
⑰ Anne Katrine Vangsgaard is awarded the title 'PhD of the year'. Photo by Thorkild Christensen.

BIOPRO WORLD TALENT CAMPUS ⑪

15-22 August

With support from the Novo Nordisk Foundation, the BIOPRO partnership hosted their second World Talent Campus in August. The World Talent Campus is an ambitious PhD course for some of the most talented students in their research area.

SEPTEMBER

INAUGURAL ANNUAL LECTURE BY PROFESSOR IGNACIO GROSSMANN ⑫

11 September

AIChE awarded Professor Ignacio E. Grossmann from Carnegie Mellon University gave a lecture on "The Role of Process Systems Engineering in Chemical Engineering" at the very first CAPEC-PROCESS Annual Lecture 2014.

KEYNOTE LECTURE BY PROFESSOR KIM DAM-JOHANSEN

16 September

At the Bio-Energy China 2014 conference in Beijing, Kim Dam-Johansen presented the keynote lecture "Towards a carbon free energy system in Denmark". The lecture was part of the 'Danish Bioenergy Seminar—Strongholds and Investment Opportunities' hosted by the Embassy of Denmark in Beijing and Invest In Denmark.

DANISH SCIENCE FESTIVAL ⑬

22 –26 September

In connection with this year's Danish Science Festival, Associate Professor Flemming Frandsen gave his famous lecture on high-temperature ash chemistry and volcanoes at two primary schools. Associate Professor Frandsen has given his lectures at ten different schools this year to share his passion for natural sciences and engineering. Furthermore, during the festival 25 science students from Skolen ved Rønnebær Allé in Elsinore (Helsingør) got a sneak peek into the life of an engineer when they visited DPC for a day in the world of plastics and polymers. The visit was arranged in collaboration with the Danish Plastics Industry.

OCTOBER

VISIT FROM PROFESSOR WEI WANG

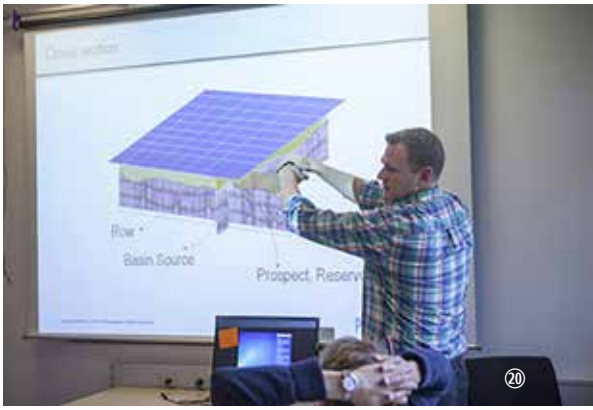
8 – 10 October

Professor Wei Wang from the Institute of Process Engineering, Chinese Academy of Sciences, and expert on modelling of multiphase flow by the so called multi-scale method, visited the Department for two days. The visit was a part of an international networking programme funded by the Danish Ministry of Science, Innovation and Higher Education, aimed to strengthen cooperation between our Department and IPE.

OFFICIAL VISIT FROM CHINA

23 October

A delegation from the China Energy Conservation and Environment Protection Group visited the Department to draw on the CAPEC-PROCESS's vast knowledge in the fields of wastewater and energy efficiency. The delegation enjoyed presentations from the Head of CAPEC-PROCESS, Professor Gernaey and industry representatives.



⑱ Professor Rafiqul Gani at the Doctor Honoris Causa ceremony. Photo by Razvan Onofrei.
⑲ Potential students learn about our BEng programmes at the DTU Open House event. Photo by Lotte Grandorf.
⑳ Teachers are acquainted with the PetroChallenge game.

OFFICIAL VISIT FROM AUSTRIA ⑭

24 November

An official delegation from the Austrian region of Styria visited DTU Chemical Engineering. Here, Professor Anne S. Meyer and Associate Professor Ulrich Krühne presented our activities in the pharmaceutical area.

2014 HEMPEL-DTU PRIZE WINNERS VISIT CAMPUS LYNGBY ⑮

28 October

In 2014, two schools who had won the Hempel-DTU prize visited Campus Lyngby to learn more about the many activities and possibilities at DTU Chemical Engineering and other DTU departments.

CONTINUING EDUCATION FOR PHYSICS AND CHEMISTRY TEACHERS

30 October

In the past five years, the DPC, together with the Danish Plastics Industry, has offered courses in plastics to physics and chemistry high school teachers. One of these courses was held October and was taught by Professor Ole Hassager. The teachers were given new inspiration and methods to incorporate in their teachings.

FLEMMING FRANDSEN RECEIVES THE FUEL QUALITY HERO AWARD ⑯

30 October

Flemming Frandsen, Associate Professor at CHEC, received the Fuel Quality Hero Award from the conference series of the same name. He received the award on basis of his dedicated work on presenting papers and reviews of lectures of the conference during many years and for his work with attracting new participants to the conference.

ANNA KATRINE VANGSGAARD NAMED PHD OF THE YEAR ⑰

31 October

Anna Katrine Vangsgaard received the PhD of the Year Award for her outstanding PhD thesis 'Modelling, Experimentation, and Control of Autotrophic Nitrogen Removal in Granular Sludge Systems' with Associate Professor Gürkan Sin as main supervisor. The reason for awarding Anna Vangsgaard with the prize was the extremely high quality of the thesis and her commitment to communicate the results.

RAFIQUL GANI NAMED DOCTOR HONORIS CAUSA ⑱

31 October

Professor Rafiqul Gani received the title of Doctor Honoris Causa by the University Politehnica of Bucharest in recognition of his outstanding achievements over a dedicated career as scientist and educator.

NOVEMBER

OPEN HOUSE EVENT ⑲

6 November

Every year, DTU invites everyone interested in studying at DTU to a big fair, where all the different educations are represented. Here, students interested in pursuing a career in engineering can learn more about requirements, study plans and content of all the different educations at DTU. Again this year, a very large number of potential students showed interest in our programmes.

㉑ Child learns about the science of LEGO at the Danish Polymer Centre (DPC)
㉒ Professor Qingshan Zhu gives his lecture 'Low-grade mineral processing through fluidized bed reactor'
㉓ Associate Professor Jakob Kjøbsted Huusom in ProBioRefine workshop at Korea Advanced Institute of Science and Technology (KAIST). Photo by Jang Bok Lee.

PETROCHALLENGE ⑳

14 November

The virtual oil exploration game, PetroChallenge, organised by CERE, that is intended to provide prospective students with an insight in oil engineering, had around 1,700 participants this year. The winning team came from Svendborg. The awarding of the first, second and third place was done during the Oil and Education Day arranged in cooperation with Maersk Oil & Gas and DONG Energy.

10TH ANNUAL POLYMER DAY

21 November

The 10th Annual Polymer Day arranged by DPC took place on 21 November. 46 participants, both representatives from the Danish plastic industry and academia, were gathered to share knowledge and research on polymers.

THE CHILDREN'S UNIVERSITY ㉑

22 November

520 children spend their Saturday at DTU to learn more about the wonderful world of materials. DPC hosted a workshop where the children had the opportunity to make experiments with a material that is well-known to most children and parents—the iconic Danish toy, LEGO.

VISIT FROM PROFESSOR QINGSHAN ZHU ㉒

30 November – 4 December

Deputy Director, Professor Qingshan Zhu from the Institute of Process Engineering at Chinese Academy of Sciences (CAS) in China visited DTU Chemical Engineering to establish cooperation in the field of mineral processing. His stay included a visit to both Lyngby and Risø campus. Professor Zhu concluded the visit with his lecture 'Low-grade mineral processing through fluidized bed reactor'.

DECEMBER

VISIT TO KAIST ㉓

1-2 December

Researchers and PhDs from the Department visited Korea Advanced Institute of Science and Technology (KAIST) in South Korea for a workshop aimed at dissemination-training based on the results from ProBioRefine project. The objective of ProBioRefine is to develop a systematic method and associated tools that can analyse and design innovative biorefinery networks based on chemical and biological approaches to convert biomass feedstock into valuable chemicals and biofuels.

CHRISTMAS SEMINAR AT THE DEPARTMENT

12 December

This year's Christmas Seminar was an informative day followed by a traditional Christmas lunch. Each research centre gave a short presentation of a successful project of 2014—some of which you can read about in the following pages.

RESEARCH CENTRES & FEATURE ARTICLES

AT CERE

AT CERE is a dynamic research group with an excellent track record and international reputation in the areas of applied thermodynamics, transport processes, and mathematical modelling.
The centre is committed to perform high-quality experimental and theoretical research with international impact. There are extensive collaborations, first of all within CERE and DTU Chemical Engineering, but also with universities and industries around the world. It shares industry consortium with CERE, which in 2014 includes 29 companies, of which 22 are international.

www.cere.dtu.dk

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In 2014 the CERE Consortium consisted of the following members:

- Akzo Nobel (NL)
- BP (GB)
- Chevron (US)
- Conocophillips (US)
- DONG Energy A/S (DK)
- Eni (IT)
- ExxonMobil (US)
- GASSCO (NO)
- GASSNOVA (NO)
- GDF-SUEZ (FR)
- Genel Energy (TR)
- Haldor Topsøe (DK)
- Hess (DK)
- IFP (FR)
- Infochem (GB)
- Linde (DE)
- Lloyd's Register ODS (DK)
- Maersk Oil (DK)
- National Oilwell Varco (US)
- OMV (AT)
- Petrobras (BR)
- RWE (DE)
- Schlumberger (US)
- Shell (NL)
- Sinopec (CN)
- Statoil (NO)
- SQM (CL)
- Total (FR)
- Welltec (DK)

LESS SALT, MORE OIL EXTRACTION

Salts that unexpectedly block valves and pipes can be very costly and cause loss of valuable time during oil extraction. However, this may soon be an issue of the past with the most recent extended UNIQUAC model developed by researchers from AT CERE.

Problematic salt

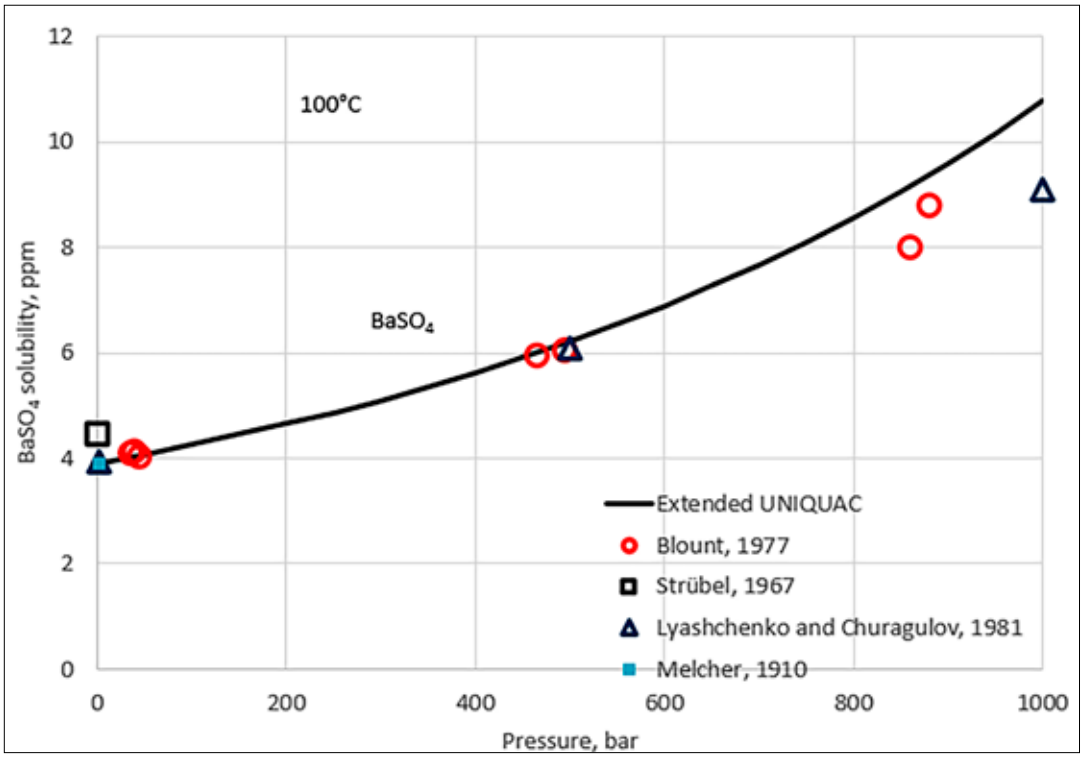
When oil companies extract oil, they extract water as well—a lot of water, in fact. This water, also referred to as 'formation water,' is usually saturated with minerals and salts from the reservoir rock surrounding it, which can turn out to be problematic when exposed to changes in temperature and pressure. The changes can cause precipitation of some of the salts due to oversaturation, a process called 'scale formation'. This causes pipes and valves to clog with salt, which requires a significant amount of time and money to clean.

Predictive model saving time and money

But now the Extended UNIQUAC model can be used to predict exactly how different types of salt will react to the changes even before the extraction begins.

"The model enables companies to examine whether the salts will be a problem, and if so, how big of a problem it will be. In that way a company can take precautions to reduce the problem significantly," says Associate Professor Kaj Thomsen, one of the researchers behind the new Extended UNIQUAC model.

When companies know the content of salts and minerals in the formation water, they can use the model to determine the risk of scale formation



The figure shows the solubility of $BaSO_4$ (barite) at 100°C as a function of pressure from 1 to 1000 bars. Experimental data from various sources are plotted together with the curve calculated with the Extended UNIQUAC model.

and thereby predict what problems they will encounter, how much it approximately will cost and which temperature changes in the reservoir the company should avoid in order to save valuable equipment.

A diverse tool with a long history

The Extended UNIQUAC model is not connected to any specific type of reservoir and can be used no matter if the oil extraction is in the North Sea, in Qatar or anywhere else in the world. And although the model is a valuable tool for the oil industry, other industries that in their operations pump up warm water can benefit from it as well. This could, for instance, be geothermal energy where an operational breakdown usually causes the temperature of the water to cool down, which can create severe scale formation. The current model includes sulphates, carbonates and chlorides, but it is being extended even further to include more substances that occur in practice such as sulphides.

"Extended UNIQUAC is one of the generic thermodynamic models we have developed in our centre. It has a long history and it has been used with success in many more applications for example modelling of CO_2 capture processes with diverse solvents. We expect to continue developing the model in the years to come", says Head of CERE, Professor Georgios Kontogeorgis.

BIOENG

Our MISSION is to conduct research that provides new knowledge, new enzymes, and new innovative process strategies for resource utilization, industrial bioconversion processes, and new products supporting a sustainable development. At the same time, we are dedicated to hatching top-qualified MSc and PhD candidates through research based teaching and structured supervision.

www.bioeng.kt.dtu.dk

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Center for BioProcess Engineering currently collaborates with the following industrial partners:

- Aminord ApS
- A.P. Møller-Mærsk A/S
- Arla Foods Amba
- Chr. Hansen A/S
- DONG Energy A/S
- DuPont A/S
- Foss A/S
- Haldor Topsøe A/S
- Hempel
- KMC
- Novozymes A/S

NEW ENZYMES FOR REFINING OF BIOMASS

Plant biomass material holds significant potential to produce new fuels, chemicals and materials, and as a source of new food ingredients. In this regard, carbohydrates have received massive research attention, while insight into how to convert lignin biocatalytically is a relatively new research area. At BioEng, Postdoc Anna Sitarz and PhD student Line Munk are well on the way to answering the riddle of how to make use of lignin. The prospects are to turn the conversion of biomass into good business.

Making lignin good business

Current biorefinery concepts often seek to exploit only the carbohydrate part of biomass, while the part consisting of lignin is combusted for internal energy consumption. Furthermore, studies show that there is a significantly higher surplus of lignin in today's biorefineries than what is needed for internal process energy. As such, there is a potential for lignin exploitation without compromising internal process requirements.

"The unutilized lignin is really important" says Line Munk, PhD student at BioEng. "As it is right now, for example second-generation biofuels are not good business, but if you are able to convert almost the entire biomass by including the lignin, then you actually have something feasible" says Line Munk.

Using laccase on lignin

Lignin is commonly known as 'the cement of trees'. It is the polymer that keeps plants water-proof and trees from collapsing. For the same reason, lignin is almost impossible to break down. Furthermore, lignin is dark-coloured and insoluble in water which makes it difficult to analyse. And, it is a complex polymer with a structure that will give most biochemical engineers a headache.

The million-dollar question on how to break it down has already been solved—although by another species. Fungi growing on trees, for example, get nourishment by eating through the bark, consequently making them experts at dissolving and restructuring lignin. Inspired by this ability, Postdoc, Anna Sitarz is researching how to structure and tune up enzymes called laccases produced from white-rot fungi in order to catalyse the modification and depolymerisation of lignin.

"I discovered that if you add cellulases to degrade the cellulose and hemicellulose, and on top of that you add laccase then you can actually boost the conversion of lignocellulose by almost 30 per cent. So, laccase, and notably the one type that we have isolated from a particular fungus called *Ganoderma Lucidum*, is definitely making a difference and we are very optimistic

Line Munk (left) and Anna Sitarz (right) in a laboratory at BioEng
Photo by: Lotte Grandorf

that this effect can impact biomass processing", says Anna Sitarz.

Adding a vehicle between laccase and lignin

In 2014, Anna—along with her supervisors, Professor Jørn D. Mikkelsen and Head of BioEng, Anne S. Meyer—investigated how the substrate range for laccases can be expanded by supplying mediators that essentially function as vehicles for electron transfer between laccases and lignin.

"When you add this extra mediator compound, the laccase seems to catalyse so that the building blocks of the lignin disintegrate, rather than polymerize. And that's what we're looking into now. One of the advantages of using laccases is also that it may utilize natural mediators in the 'biomass soup', which is much better for the environment", says Anna Sitarz.

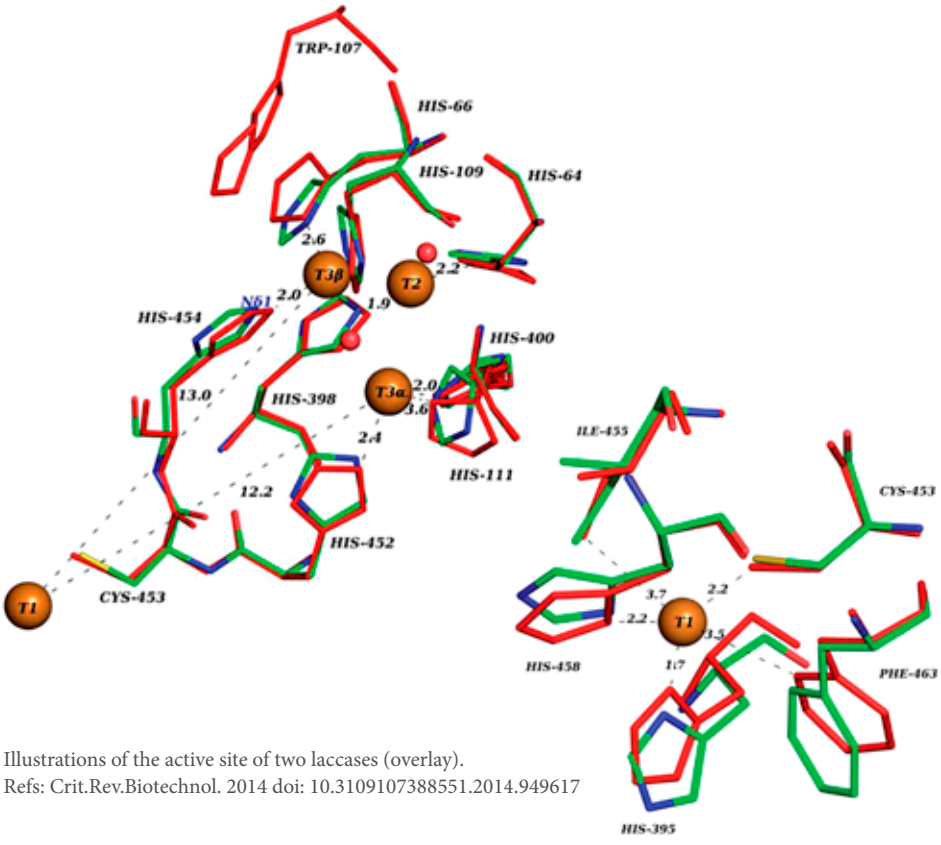
"In nature, certain fungi can degrade lignin enzymatically. This process is important to understand and we know that laccase has a key role. When we understand laccase, we will be able to combine it with other enzymes and make an optimal cocktail for biomass" concludes Line Munk.

New enzymes for degrading pectinacous plant biomass

In addition to examining how to modify lignin with enzymes, 2014 has also been the year where PhD students from BioEng have discovered, characterized, and even modified enzymes for selective upgrading of pectinaceous biomass.

"At BioEng, we have several PhDs who have undertaken detailed examinations of enzymes with 'idiomatic' names such as rhamnogalacturonan lyase, xyloglucan hydrolase, endo-1,4-β-galactanase and Prt1. This work has delivered important new

Organosolv pulverized lignin used for the projects of Line Munk and Anna Sitarz



Illustrations of the active site of two laccases (overlay).
Refs: Crit.Rev.Biotechnol. 2014 doi: 10.31091073885512014.949617

knowledge about how these enzymes work, along with a better understanding of their thermal robustness in relation to the significance of specific amino acids in their structures" says Professor Anne S. Meyer.

The new enzymes will help ensure a sustainable use of plant biomass for biorefinery processes and as a source of food ingredients and building blocks for new fuels, chemicals and materials in the future.

Facts

Main deliveries of the Laccase enzymology project:

- The reaction details of the catalytic four-copper mechanism laccase-mediated catalysis was carefully re-examined and clarified.
- Comparisons of amino acid sequences and structural traits of selected laccases revealed conservation of the active site trinuclear center geometry but differences in loop conformations.
- Key features and regions of laccases identified in relation to modification and evolution of laccases for various industrial applications including lignocellulosic biomass processing.

CAPEC-PROCESS

The research activities of CAPEC-PROCESS are performed in close collaboration with the chemical, petrochemical, pharmaceutical and biochemical industries, and are divided into three areas: Process Systems Engineering (PSE), Process Intensification (PI) and BioProcesses (BioP):

Chemical products and processes form the foundation supporting CAPEC-PROCESS research in PSE, where the focus is on developing computer-aided methods and tools for solving complex problems.

Research within the PI area aims at developing more efficient processes, and includes research activities within model-based process intensification and equipment-based process intensification and new unit operations.

In the field of BioProcesses (BioP) the centre has significant activities within biocatalytic processes and development of novel technological solutions for fermentation processes.

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In 2014, the CAPEC-PROCES Consortium consisted of the following members:

- Akzo Nobel, NL
- AlfaLaval Copenhagen, DK
- AstraZeneca UK Limited, UK
- BASF AG, DE
- Bayer Technology Services, DE
- DSM, Viktor Wallimann, CH
- DuPont Nutrition and Biosciences Denmark ApS, DK
- Einar Willumsen A/S, DK
- Firmenich SA, CH
- GlaxoSmithKline, USA
- Harper & Vedel, DK
- Huntsman Europe, BE
- Janssen Pharmaceutica N.V., BE
- Lonza AG, CH
- Mitsubishi, JP
- Neste Jacobs Oy, FI
- Novozymes A/S, DK
- Optience Corporation, USA
- Pfizer Inc, USA
- Processium, FR
- ProSim, FR
- Schneider Electric (former: Invensys: Simsci-Esscor), US
- SCG Chemicals Co., Ltd., TH
- Syngenta, UK

A GREAT PLACE TO BE AN INTERNATIONAL PHD

Rita Lencastre came to Denmark from Portugal in 2005 as an exchange student. She was meant to stay for only ten months, but almost eight years later she defended her PhD thesis in Denmark at the PROCESS centre, now CAPEC-PROCESS. Later she started at the centre as a postdoc and now, after many exciting years at DTU Chemical Engineering, she has the job of her dreams at one of the world's leading medical companies, Novo Nordisk in Denmark.

An international research centre

Every year, thousands of students from around the world travel to Denmark to take part of their education. Many of them decide to do so at DTU Chemical Engineering. While some decide to go home when the semester ends, others choose to pursue a PhD degree or another scientific job. Since 2007, the Department has almost doubled its number of international scientific staff, which currently represents 37 different nationalities. CAPEC-PROCESS is a centre that has a high number of international scientific staff members. One of them used to be Rita Lencastre from Portugal.

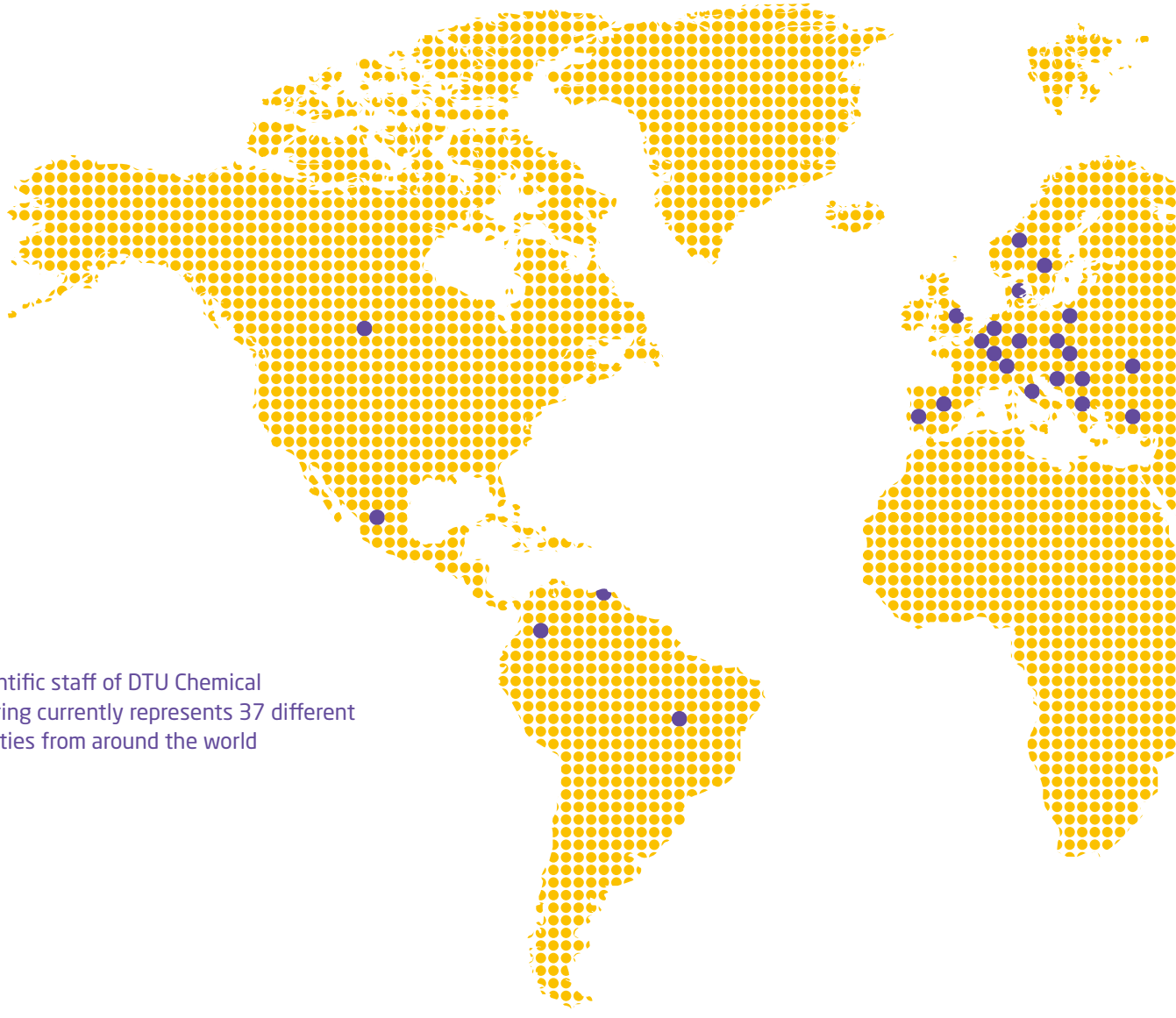
"Before I left Denmark after finishing my exchange, I tried to see, what my possibilities for coming back were", says Novo Nordisk engineer, Rita Lencastre.

So, in 2007 Rita packed her laptop again to do her MSc thesis at the former PROCESS centre. "A PhD student was working on a project about microreactor technology, and as an MSc student you usually get to work on a side-project connected to a PhD project", Rita Lencastre says.

After handing in her MSc thesis, Rita Lencastre went to work for a short while in a small consultancy company in Portugal and the US . However, DTU soon drew the ambitious scientist back—this time to work at the Department as a PhD student.

A PhD in collaboration with industry

CAPEC-PROCESS has close relationship with enterprises through its industrial consortium, which gives researchers and industrial members a chance to network and the students to test their research on real-life issues of the companies. And, especially the prospect of working with applied science on a real industrial problem was a determining factor for Rita Lencastre's return.



The scientific staff of DTU Chemical Engineering currently represents 37 different nationalities from around the world

"I still knew many people in Denmark. I also knew I didn't want to work in the lab. I would rather do a PhD where I could focus on mathematical modelling, on production process development and large scale processes, with future application of my PhD research work in industry," Rita Lencastre explains.

No hierarchies, plenty of influence

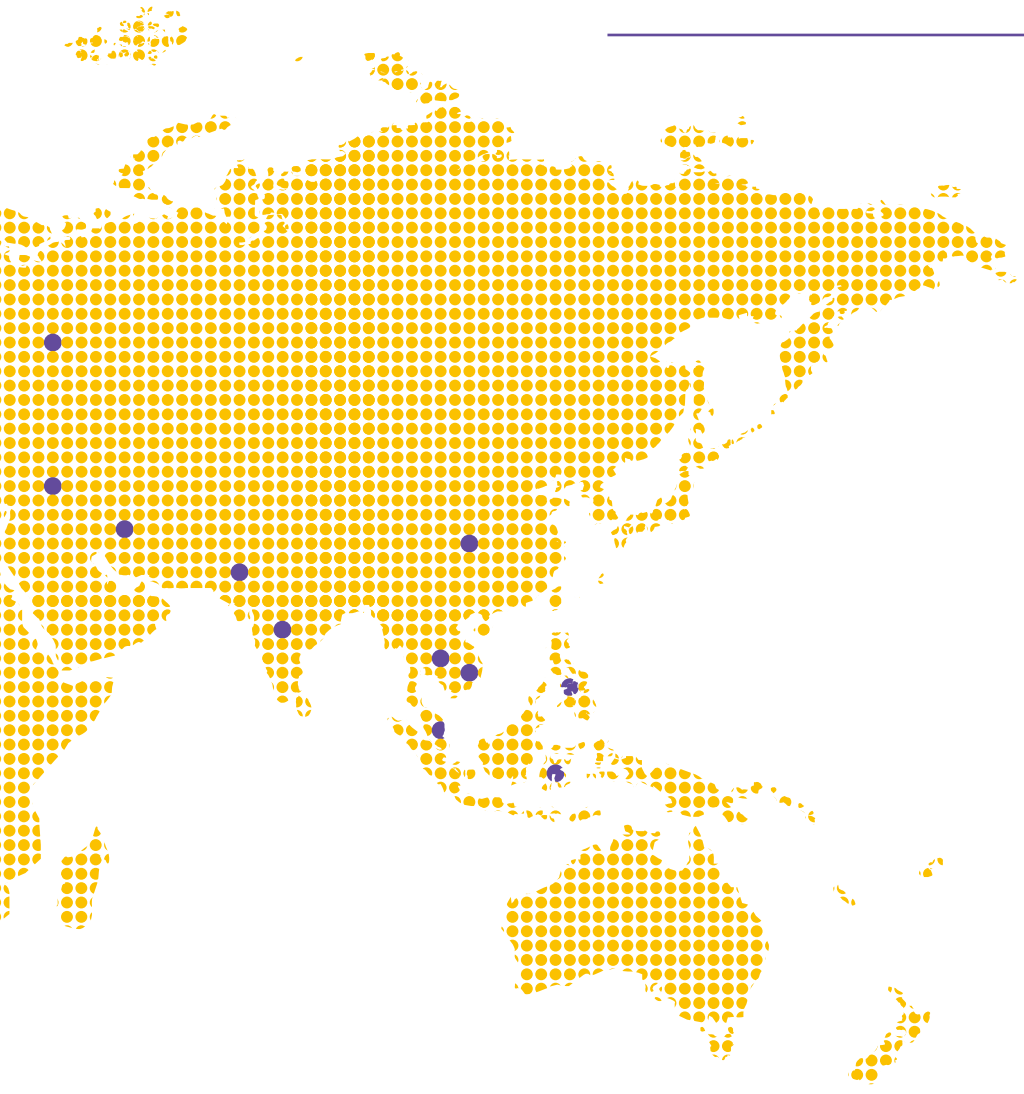
Rita Lencastre is happy that she chose Denmark.

"What I liked about Denmark was the fact that the hierarchy is somewhat loose. You can stop by the office and talk to a professor. The door is always open," Rita Lencastre says and continues, "And here you can express your opinion and be heard. This means you can make your own choices and you have stronger influence on your own education," Rita Lencastre concludes.

Rita also contributed to shaping the projects she was involved in at DTU Chemical Engineering. As a post-doc, she took part in the workshops that were organized for defining the research basis and future aims of the BIOPRO project which aims to create a world leading biotech cluster by uniting the forces of top universities and biotech companies.

European projects and international conferences

For the scientific staff members at CAPEC-PROCESS there is much to look forward to in 2015. This year, Professor Rafiqul Gani, former Head of CAPEC, started his term as President of European Federation of Chemical Engineering (EFCE). Furthermore, Professor Gani together



Rita Lencastre in front of building 227 where her office used to be

with his faculty colleagues and co-workers at CAPEC-PROCESS are hosting the 12th PSE and 25th ESCAPE joint conference in Copenhagen.

"I am looking forward to welcoming many familiar, but also many new, bright minds from academia and industry all over the world to this major event. We are providing a forum where students, researchers, engineers, experts, and others from the PSE-CAPE community and beyond can learn about recent developments as well as share their latest results and ideas, establish or renew contacts and collaborations and much more. We hope this gathering of people from around the world will motivate and encourage our staff to lift their research to an even higher level", says Professor Rafiqul Gani, President of the EFCE.

The PSE2015/ESCAPE25 conference takes place in Copenhagen on 31 May–4 June 2015.

CHEC

CHEC's main activities cover industrial high temperature processes, emissions control, catalysis and catalytic processes, particle technology, product design and production. The main disciplinary research is within reaction engineering and transport processes and cover theoretical modelling based on experiments carried out from microscale over pilot plants to full-scale industrial production plants. The research is carried out in close cooperation with industrial companies.

www.chec.kt.dtu.dk

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The CHEC Research Centre primarily collaborates with the following industrial partners

- Alfa Laval A/S
- Babcock & Wilcox Vølund ApS
- B&W Energy A/S
- DONG Energy A/S
- FLSmidth A/S
- H. Lundbeck A/S
- Haldor Topsøe A/S
- Hempel A/S
- Hwam A/S
- MAN Diesel & Turbo A/S
- Maersk A/S
- Novozymes A/S
- Topsøe Fuel Cell A/S
- Vattenfall AB

FROM COAL TO BIOMASS THROUGH FUNDAMENTAL AND FULL-SCALE SCIENCE

In a sustainable future, thermally based power production will still be needed in order to balance the fluctuating power production from renewable energy sources such as wind and solar power. However, this will also require power plants to replace fossil fuels, mainly coal, with biomass. Nevertheless, the Danish power plants are not fully developed for biomass, and transformation poses considerable technical challenges—challenges that Professor Peter Glarborg and CHEC researchers are addressing through research ranging from a molecular level and all the way to the scale of a large power plant.

Towards 100 per cent biodust combustion

Already back in 1994, researchers from CHEC initiated full-scale work on thermal biomass conversion processes, and in 2011 the Centre for Power Generation from Renewable Energy (GREEN) was established as part of CHEC to provide the scientific basis for designing future power plants for 100 per cent biodust combustion. GREEN is headed by Professor Peter Glarborg and is the collaboration between several power plants and international universities. This year, the researchers of GREEN have delivered significant results to help solve issues with corrosion control, particle combustion and ash deposition.

Understanding the molecular chemistry of ash to control corrosion

One of the major challenges to the conversion to biomass is the higher risk of corrosion. Compared to coal-firing, the biomass ash deposits are rich with chlorine and alkali metal which causes increased corrosion of boiler coils. To solve this issue, the researchers of GREEN investigated how alkali metals can be bound in species that are less corrosive than alkali chloride. Peter Glarborg explains, "We are the first in the world to develop a model that describes the interaction between alkali, chlorine and sulphur species at a molecular level in the gas-phase at high temperatures. In GREEN, Researcher Hao Wu and co-workers have used this model, supported by experiments, to show how the corrosion can be limited by injection of selected sulphates into the furnace at specific temperatures".

New particle models for biodust combustion

Corrosion is not the only challenge the power plants are facing when phasing out coal.
"Flames behave differently when you change the size of fuel particles as you do when you convert to biomass. For example, if the particles are too big they will shoot through the flame which means you won't get an effective burnout", says Associate Professor Peter Arendt Jensen.

To study the biomass particle devolatilisation process—an important step of the combustion process—PhD students Joakim Myung Johansen and Anna Trubetskaya have visited Stanford University and the Technical University of München, respectively. The data they gathered abroad—together with pilot scale experiments at DTU and the Technical University of Clausthal—form the basis for the development of new, more accurate biomass particle combustion models, which can be used as a part of larger Computational Fluid Dynamics (CFD) models of biomass flames. The CFD models can then be used to predict flame stability, ignition and biomass burnout in full-scale boilers.

Recording the structure of large flames

The CFD modelling of flames has also been verified through full-scale flame measurement campaigns at two Danish power plants in Amager and Herning. The measurements were carried out by Senior Scientist Sønnik Clausen and his team who placed optical probes inside the flame and recorded the movements of fuel particles within the flame using a video and high speed thermal camera.

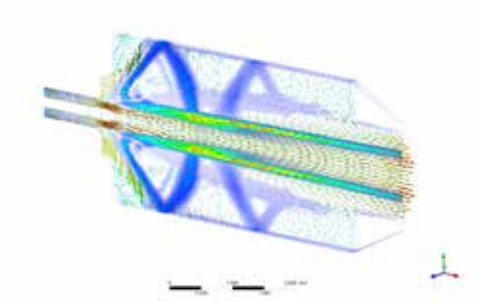
"As a power plant manager, you want to be able burn many different types of fuels. At the same time, you want to be able to control the flame, you want the flame to be stable so it doesn't flicker or blow out. And, you want an effective mixing of air and fuel with good burnout and low emissions of harmful gases. This detailed information on flame properties can be obtained by using the advanced optical measuring equipment", Sønnik Clausen explains.

Full-scale measuring of ash deposition

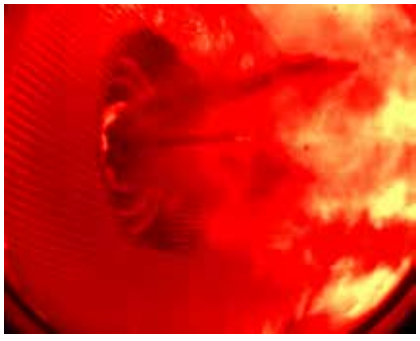
The challenge of ash deposition is not new. For almost 20 years the CHEC research centre has been placing deposit probes in the power plant boilers of DONG Energy and Vattenfall to determine how ash deposition builds when using biomass fuels. With the GREEN project these probe measurements have been collected to provide a unique understanding of the deposit formation and removal of biomass ash deposits that is essential for the reliable operation of biomass boilers. The results have not only answered some important questions, they have also ignited some new ones.

"It doesn't end here", says Peter Arendt Jensen and continues, "right now, we're working in the labs to better understand how the single ash particle

◂ Associate Professor Peter Arendt (left) and PhD student Joakim Myung Johansen (right) are working on the single particle experimental set up, which is used to investigate biomass particle combustion and pyrolysis at high temperatures.



Full-scale CFD modelling of a 30 MW bio-dust flame: Velocity field and fluid and combustion of bio-dust.



Thermal image of pulverised wood flame in the power plant of Hofor. The dark structures are wood particles leaving the burner. Probe for measurement of temperature and gas composition is inserted through the centre of burner.

Video image of pulverised wood flame in the power plant of Hofor. Flame light from soot particles at burner exit indicated ignition. The measurements were done in collaboration with Johan Wadenbäck.

material properties influence how it moves and sticks to hot surfaces. Based on this work we want to produce new and improved computer models that describe biomass ash deposit behaviour in boilers. Being able to predict how fast and how much it builds up should lead the way for improved boiler on site deposit removal and thereby minimize unwanted, expensive boiler shut downs," Peter Arendt explains.

"It's great to see how our joint activities with biomass conversion in the early 1990s has secured real progress in biomass utilization in full-scale power plants, and to see how it has inspired international cooperation in GREEN", says Professor Kim Dam-Johansen, Head of CHEC.

In 2014 the GREEN project has been extended to GREEN 2 which will deliver its final results in 2017.

Want to know more?

Go to: www.chec.kt.dtu.dk/Projects/GREEN

Facts

GREEN collaborations

The GREEN project is a research collaboration between DTU Chemical Engineering, DTU Mechanical Engineering, Aarhus University – Agroecology and Environment, Hochschule für nachhaltige Entwicklung Eberswalde, Lund University, Stanford University, University of North Texas, B&W Energy, DONG Energy Power and Vattenfall. The centre is financed by the Danish Council for Strategic Research, Danish Agency for Science, Technology and Innovation.

GREEN objectives

The objective of GREEN is to facilitate the development of a new generation of power plants, designed for 100 per cent biodust combustion, by addressing the technological constraints related to biomass combustion. Furthermore, GREEN wishes to address the need for improving the availability and quality of biomass through a more efficient international biomass trading and use of optimized energy crops. GREEN encompasses the full cycle of power plant conversion to biomass fuels as it includes:

- finding new ways to optimize crops for high energy biomass
- supporting the development of burner designs that can burn many types of biofuel
- optimizing methods to reduce deposition and corrosion
- Improving flue gas cleaning
- re-using the ashes as fertilizer in agriculture

DPC

The vision of The Danish Polymer Centre is to serve society by training candidates for the polymer industry and for the public sector. We are devoted to the application of molecular design, synthesis and processing of polymers to create materials and products with unlimited ranges of properties and applications. We strive towards this goal in a balanced environment of education, research and industrial cooperation.

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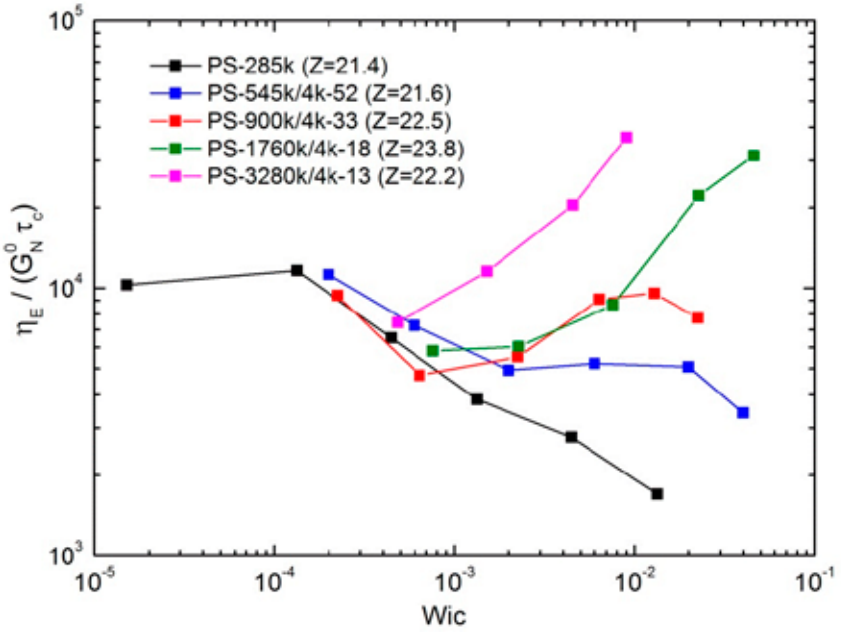
- Alfa Laval Nakskov A/S (DK)
- Coloplast A/S (DK)
- Dana Lim A/S (DK)
- Dyrup A/S (DK)
- Grundfos Management A/S (DK)
- Hempel A/S (DK)
- Novo Nordisk A/S (DK)
- Tetra Pak Packaging Solutions AB (SE)
- Bang&Olufsen
- LEGO
- Radiometer Medical
- Mærsk Olie & Gas, Qatar Research
- Wavestar
- ESS Technology
- Danfoss PolyPower

WHEN THE ANSWER IS IN THE SOLUTION

Basic science can sometimes yield surprising results that are not only useful in terms of creating a better understanding of a specific field, but also in terms of improving the way we do things in everyday life. Likewise, Postdoc at DPC, Qian Huang's quest to better understand the behaviour of extensional viscosity of polymers produced surprising results that will bring much-needed answers to both theoreticians and practitioners in the field of rheology.

Theory and practice did not add up

In 2003, a PhD student at the Danish Polymer Centre (DPC) named Anders Bach, was the first to challenge Nobel laureate, Pierre-Gilles DeGennes' widely accepted theoretical predictions of the universal behaviour of extensional viscosity as function of the extension rate. Contrary to the existing theory at the time, Anders Bach's experiments with entangled polymers showed that they in fact did not behave the same way in melts and solutions. For more than a decade, this difference between theory and experiments has been nagging the rheology community. This until a young Chinese PhD student (now postdoc) at DPC, named Qian Huang came up with an idea that would finally unravel the mystery of why melts and solutions behave differently, when—according to existing theory—they should not.



The figure shows the normalized extensional viscosity as a function of the normalized stretch rate for five polystyrene solutions. The solutions contain different concentrations of polystyrenes from 10% (pink curve) to 100% (black curve). The figure reveals that the nonlinear rheological behavior of polymer chains is not universal but concentration dependent.

Qian Huang working in one of the laboratories of DTU Chemical Engineering.

Unravelling the mystery of the entangled polymers

To determine why this difference occurred, Qian Huang designed a series of polystyrene polymer solutions that enables an almost continuous path between entangled melts and entangled solutions. The solutions increased in concentration from 10% polymer and 90% solvent to 100% polymer. Consequently, she was able to piece together a full view of the behaviours from melt to solvent, thus demonstrating that extensional viscosity is concentration-dependent rather than universal, as previously believed.

From basic science to practical impact

Although Qian Huang's basic science has been driven by curiosity and a love of the field of rheology, the findings are also important to industry. "A more comprehensive knowledge of the behaviour of materials in for example, the plastic industry means better control of processing and fewer batches with defects which are expensive mistakes that can be devastating to a business", says Qian Huang.

But Qian Huang's work is not yet finished. There is still a need to find out the physical mechanism behind the concentration dependence, which requires more experiments on different polymers.

ECO

The ECO centre at DTU Chemical Engineering conducts research to understand and demonstrate environmental impacts of technologies and industrial processes in chemical and biochemical engineering in order to assess and analyse environmental sustainability.

Collaboration and scientific advice

We collaborate with universities, EU, policymakers, public companies and private industry. We hereby apply concepts and results derived from our research to practical problems. In this way we also ensure dissemination of our research.

www.eco.kt.dtu.dk

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Professor Per Ambus, former Head of ECO, resigned 1 December 2014

Ecosystems and Environmental Sustainability currently collaborates with the following industrial partners

- AgroTech (DK)
- Air Liquide (DK)
- Boreal (FIN)
- Bregentved Estate (DK)
- Carlsberg (DK)
- DLF Trifolium (DK)
- DONG Energy (DK)
- GCM (DK)
- GramiNor (NO)
- HedeDanmark (DK)
- Hempel (DK)
- LI-COR Biosciences (US)
- Nordic Seed (DK)
- Novozymes (DK)
- Sejet Plant Breeding (DK)
- SW Seed/Lantmännen (SE)
- Videncenter for Landbrug (DK)

UV-LIGHT INDUCES N_2O EMISSION FROM PLANTS

Plants emit nitrous oxide (N_2O) when exposed to UV-light. This was found by researchers Teis N. Mikkelsen, Per Ambus, Kristian R. Albert from the ECO Centre and Dan Bruhn from the Open University (UK). While it is known that bacteria in soils and waters on the Earth's surface are significant contributors to the naturally occurring N_2O emissions that contribute to global warming and deplete the ozone layer, it is the first time that research has shown that plants are not only conductors of these soil emissions, but in fact emit N_2O themselves when exposed to UV. Since vegetation as a source of N_2O emission has never been accounted for before, and since the findings indicate that ecosystem emissions of N_2O may be up to 30% higher than previously assumed, a re-calculation of current emission budgets is needed.

The significance of UV

At the American Geophysical Union congress in San Francisco in 2007 two groups presented a new finding: Natural ultra violet light stimulated the release of the greenhouse methane from plants. One of the groups consisted of scientists from the ECO centre. Since then, the group has been working with light stimulated gas emissions from vegetation and shown that UV also induces carbon monoxide emission. And, in 2014, the group has demonstrated a new finding: UV stimulated N_2O emission from plants.

Sunlight and temperature as catalysts for plant emission

Ultraviolet radiation (UVA+UVB) from naturally occurring sunlight along with warm temperatures increase the N_2O emission from plants. This conclusion was reached through an investigation of the N_2O atmosphere exchange from grass vegetation exposed to solar irradiance with and without UV-screening. Furthermore, these field site measurements were tested against controlled laboratory tests also with different plant species. The field site measurements were conducted in a newly developed UV-transparent acrylic plastic chamber that was placed in a water filled groove on top of a metal collar pushed into the ground. The chamber headspace temperature was continuously monitored and air was mixed by a fan. The light quality was controlled

by inserting UV opaque filters when needed. The real-time measurements of N_2O concentrations were conducted by state-of-art equipment: Enhanced cavity spectroscopy by a N_2O/CO analyser. This is the first instrument capable of continuously measuring ambient levels of nitrous oxide with precision better than 0.1 ppb in 1 second. The analyser was connected in closed-loop to the ecosystem chamber or the leaf chamber.

Based on the results of these measurements, it is likely that some ecosystems will emit more N_2O than others, since UV radiation and temperatures are higher, for instance, around the equator. Therefore, the research group is hoping to retrieve funds to conduct a global examination of this previously undescribed mechanism.

Emission comes from the leaves

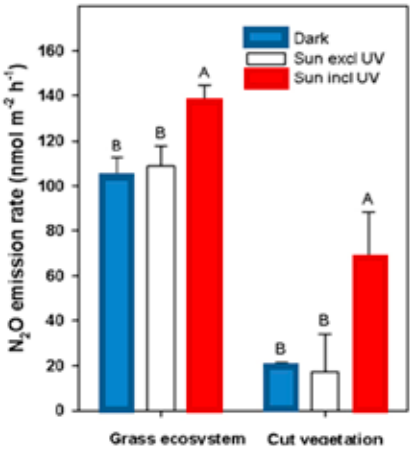
The very surface of leaves appears to be the prevailing zone for the N_2O formation. And, as the surfaces of plants vary from large and waxy to small and spiky, so does the degree of N_2O emitted from them. Furthermore, the results showed that only 26% of the nitrogen (N) embedded in UV-induced N_2O seems to come from the plant.

"This means the remaining N_2O-N is coming from some unknown source. We also don't know how much N_2O plants are responsible for in the global total of greenhouse gases. Therefore, further research is needed in order to understand the mechanisms and sources behind this new discovery", says Teis N. Mikkelsen, Senior Scientist at ECO.

Re-calculation of climate budgets needed

Based on the group's laboratory and field experiments, the N_2O released from plants when exposed to UV-light can possibly account for up to 30% of the natural sources. If the figure turns out to be this high, decision-makers such as the International Panel of Climate Change (IPCC) will have to account for plants in the overall climate budget in order to be able to decide what steps to take against climate change.

"You may ask, if it's such a significant source, why haven't you found out about this before? Well, compared to other more concentrated sources such as agriculture, fossil fuel combustion or wastewater management, plants are a very 'weak' source. Nevertheless, there are so many of them distributed all over the Earth, which means the potential impact is very high. This is also the reason why I believe it's important to investigate further", concludes Teis N. Mikkelsen.



Field measurements of N_2O emissions in a Danish grassland. Grass ecosystem = intact soil and plants. Cut vegetation = cut vegetation shoots isolated from soil with a membrane. Dark simulates the hitherto N_2O measurement in ecosystems, Sun excl UV = PAR (90%) transparent ecosystem chamber & Sun incl UV = PAR (90%) and UV (83%) transparent ecosystem chamber (Bruhn et al., 2014b).

Senior Scientist, Teis Mikkelsen.
Photo by: Lotte Grandorf

Facts

N_2O, also known as laughing gas, is a naturally occurring greenhouse gas. While its oxidizing properties for instance are used in medicine and for engine optimization today, N_2O along with carbon dioxide, methane and ozone also plays a significant role in the global warming.

Main findings:

- Plants released N_2O in natural sunlight, mostly due to UV.
- The emission rate is temperature dependent.
- The N_2O formation appears to be at the surface of leaves.
- Ecosystem emission of N_2O may be up to c. 30% higher than previously assumed

THE ROAD TO SUCCESSFUL COOPERATION WITH CHINA

The very first students of the ambitious research-based MSc programme in Chemical and Biochemical Engineering at the Sino-Danish Center for Research and Education (SDC) in China will graduate in 2015. They will get a double degree with a focus on theoretical, experimental and practical aspects of chemical and biochemical engineering that are of relevance to product design, process design and production in chemistry, biotechnology, food, pharma, and energy. The relevance of the programme is continuously secured through a close collaboration with industry. A collaboration that benefits both students and companies.

Establishing relations between academia and industry

In ancient times, it was the Silk Road that connected the tradesmen of Europe and Asia. Today, programmes such as the MSc in Chemical and Biochemical Engineering at SDC in Beijing represent a new 'academic Silk Road' connecting students, researchers and companies in China and Denmark.

"Our aim of collaborating with SDC is to facilitate the long-term connection of students and companies with activities in China and Denmark," says Head of Department Professor Kim Dam-Johansen, and continues, "this year, for example, 16 students from SDC visited our Department to participate in a 7-week Summer University course. The visit has been made possible through sponsorships from DTU, SDC and generous funding from Hempel, Novozymes and Haldor Topsøe—companies with fast-expanding business in China" says Kim Dam-Johansen.

The collaboration with industry is not only limited to funding the students' visit to Denmark. The students are also invited into the production and research facilities of the companies where they are introduced to some of the real-life issues that the companies are facing. Furthermore, the companies are invited to give presentations of their activities in China and future engineering needs as part of the programme. In this way, the SDC programme yields benefits for the Chinese and Danish students, and the collaborating companies, Haldor Topsøe, Hempel, Novozymes and the two nations.

Engineers with a cross-cultural approach

As in the days of the Silk Road there are many benefits to collaborating with China—both economically and academically. To Haldor Topsøe, China is an important growth market for the technologies of their company—especially right now.

"We are building a new factory in China, so we expect to increase our activities significantly. Therefore, our collaboration on the education of both Danish and Chinese engineers is exactly what our organization needs. The graduates will have unique knowledge of how to solve complex problems using a cross-cultural approach. In this way, they are essential to a successful expansion in China," says Bjerne Clausen, CEO of Haldor Topsøe.

Dressed for success in the Chinese market

The programme familiarizes the students with Chinese customs and gives them experience with working efficiently in a culturally diverse team

This year, 16 students from our Master's programme at the SDC in China travelled to DTU Chemical Engineering to participate in our Summer University courses and the DTU competition Grøn Dyst (Green Challenge). During their 7-week stay, the students were invited into the facilities of the Danish companies Hempel, Haldor Topsøe and Novozymes. Besides sponsoring the students' trip to Denmark, the three companies gave the students a rare insight into the practical application of their education.

as well as a unique in-depth insight into the Chinese market. Henrik Teglborg, student at SDC, believes the programme prepares them for a better consultation to the companies.

"It's an advantage that we can go straight out to the companies with knowledge of the markets that they are actually operating in", Henrik Teglborg explains.

CEO of Hempel, Pierre Yves Jullien agrees.
"In our business, research across national boundaries is essential to success. For that reason, we are looking for knowledgeable and highly competent people who can fit in with our extensive worldwide representation. In this connection, our longstanding collaboration with DTU Chemical Engineering is very beneficial as they understand our needs and are able to attend to these needs with an international perspective", says Pierre Yves Jullien.

Sustainability on the agenda

With the MSc programme the students also get a chance to work with the industry's need for sustainable solutions. In the summer of 2014, when the SDC students visited our Department, they participated in the DTU Green Challenge competition. Here, one of the teams won 2nd place for their project, "Treatment and reuse of dairy waste water by membrane technology".
And, the sustainable and environmentally acceptable production processes are in high demand according to Per Falholt, Group Vice President of Novozymes.

"As a large-sized enterprise we have a responsibility to consider ways to reduce environmental harm in our production processes—now and in the future. Therefore, graduates that have an understanding of the two countries' differences in perspectives and methods for performing sustainable engineering are in high demand at Novozymes," says Per Falholt.

Open for collaboration

The new MSc programme is constantly developing.

"In 2015 we are opening up for collaboration with even more companies in the fields of chemistry, biotechnology, food, pharma and energy, which have significant activities in Denmark and China", encourages Kim Dam-Johansen.

SUMMER UNIVERSITY: A PREVIEW INTO REAL-LIFE ENGINEERING

Since 2007, the Department has invited students from all over the world into its pilot plant for a 4-week course on unit operations. The course is called Summer University in Process Engineering and its purpose is to ensure competent engineers who are well prepared to venture into to the real world. 2014 was the year where the number of Summer University students reached a record with almost 100 international students from the US, Europe and China.

Summer University student, Megan Torman from Alabama University during one of her classes in the pilot plant of DTU Chemical Engineering

Group photo of excited students marking the conclusion of this year's Summer University

Away from the desk

"Here at DTU Chemical Engineering, we believe that being a real engineer does not only include sitting at a desk and knowing things in theory, but also seeing and experiencing how things work in real life", says Technical Manager and responsible for the Summer University, Lars Kiørboe.

One of the visiting students was 20-year old Megan Torman from Alabama University in the US. She is graduating in spring 2015 with a major in chemical engineering, minor in math, and an MBA in May 2016. To Megan, the Summer University provided the opportunities she had hoped for.

"I decided to come to Denmark because it was a great opportunity to expand my cultural experience, meet new people, learn in a first-class laboratory, and see a different part of the world. It was everything I had hoped for and more", says Megan Torman.

Emily Daleo recieves her hard-earned diploma from Professor Mario Eden, Department Chair of Auburn Chemical Engineering

Working on an entire process

According to Lars Kiørboe, the quality of the pilot facilities of the Department, are unlikely to be be matched anywhere in the world, as many universities for economic and practical reasons have reduced their large scale activities. The pilot plant consists of a series of single processing set-ups that demonstrate the chemical unit operations. Those are the building blocks on which chemical processing plants are built of. In introductory courses like the Summer University, the units are used as single assignments, but in advanced courses the students are challenged to put together many unit operations in order to simulate an entire manufacturing process.

"As a technical university, we need to keep up with the demands of the real world and we want to continue to offer the best, most realistic facilities to our students. Therefore, the constant development of our pilot plant is of great strategic importance"says Professor Kim Dam-Johansen, Head of Department.

The application deadline for the next Summer University is 17 April 2015.

PRODUCTIVITY

Productivity
Publications
Education

Number of students (STÅ). One STÅ is the equivalent of one student studying full time in a year

2014:

223 STUDENTS

2012:

192 STUDENTS

2007:

167 STUDENTS

PRODUCTIVITY

TEACHING & EDUCATION 2014

STUDENTS, EDUCATIONAL RESOURCES AND IMPACT

Students (STÅ*)	**223**
Completed BSc and BEng projects	**26**
Completed MSc projects	**54**

* One STÅ is the equivalent of one student studying full time in a year

RESEARCH & INNOVATION 2014

1.1.2014 – 30.11.2014

Scientific articles with referee in ISI-indexed journals (WoS)	**160**
Contributions to books	**6**
PhD Theses	**36**
Patents and patent ideas delivered to DTU	**16**

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Open Journal of Forestry, Vol. 4, 2014, p. 197-207.

Li, Jing; Chen, Xiangrong; Qi, Benkun; Luo, Jianquan; Zhuang, Xiaojie; Su, Yi; Wan, Yinhua / **Continuous Acetone-Butanol-Ethanol (ABE) Fermentation with in Situ Solvent Recovery by Silicalite-1 Filled PDMS/ PAN Composite Membrane.** The Open Energy & Fuels Journal, Vol. 28, No. 1, 2014, p. 555–562.

Contributions to books

Kemausuor, Francis; Yakah, Evans; Kamp, Andreas / **Regional Assessment of Agricultural Residues for Bioenergy Production in Ghana.** Ghana: Social, Economic and Political Issues.. ed. / C. Roscoe. Nova Science Publishers, Incorporated, 2014. p. 147-174.

Lutze, Philip; Gani, Rafiqul / **Process intensification in integrated membrane processes.** Integrated Membrane Operations. ed. / Alfredo Cassano; Enrico Drioli. Walter de Gruyter, 2014. p. 25-57.

Matyssek, Rainer; Knoke, Thomas; Clarke, Nicholas; Cudlin, Pavel; Mikkelsen, Teis Nørgaard; Tuovinen, Juha-Pekka; Wieser, Gerhard; Paoletti, Elena / **Conclusions and perspectives.** Climate Change, Air Pollution and Global Challenges: Understanding and Perspectives from Forest Research. ed. / Rainer Matyssek; Nicholas Clarke; Pavel Cudlin; Teis Nørgaard Mikkelsen; J-P. Tuovinen; Gerhard Wieser; Elena Paoletti. Elsevier Science, 2014. p. 591-607 (Developments in Environmental Science, Vol. 13).

Mikkelsen, Teis Nørgaard; Clarke, Nicholas; Danielewska, Alina; Fischer, Richard / **Towards supersites in forest ecosystem monitoring and research.** Climate Change, Air Pollution and Global Challenges: Understanding and Perspectives from Forest Research. ed. / Rainer Matyssek; Nicholas Clarke; Pavel Cudlin; Teis Nørgaard Mikkelsen; J-P. Tuovinen; Gerhard Wieser; Elena Paoletti. Elsevier Science, 2014. p. 475-495 (Developments in Environmental Science, Vol. 13).

Paoletti, Elena; de Vries, Wim; Mikkelsen, Teis Nørgaard; Ibrom, Andreas; Larsen, Klaus Steenberg; Tuovinen, Juha-Pekka; Serengil, Yussuf; Yurtseven, I.; Wieser, Gerhard; Matyssek, Rainer / **Key lindicators of air pollution and climate change impacts at forest supersites.** Climate Change, Air Pollution and Global Challenges: Understanding and Perspectives from Forest Research. ed. / Rainer Matyssek; Nicholas Clarke; Pavel Cudlin; Teis Nørgaard Mikkelsen; J-P. Tuovinen; Gerhard Wieser; Elena Paoletti. Elsevier Science, 2014. p. 497-518 (Developments in Environmental Science, Vol. 13).

Stolpe, Mathias; Buhl, Thomas; Sumer, B. Mutlu; Kiil, Søren; Holbøll, Joachim; Piirainen, Kalle / **Offshore wind energy developments.** DTU International Energy Report 2014: Wind energy — drivers and barriers for higher shares of wind in the global power generation mix. ed. / Hans Hvidtfeldt Larsen; Leif Sønderberg Petersen. Technical University of Denmark, 2014. p. 43-51.

Examples of scientific reports

Jensen, Peter Arendt; Trinh, Ngoc Trung; Dam-Johansen, Kim; Knudsen, Niels Ole; Sørensen, Hanne Risbjerg / **Treatment of lignin and waste residues by flash pyrolysis : Final report.** Technical University of Denmark, Department of chemical and Biochemical Engineering, 2014. 146 p.

Stockmarr, Anders; Ersbøll, Bjarne Kjær; Kotwa, Ewelina Katarzyna; Thyregod, Camilla; Thommesen, Jacob; Duijm, Nijs Jan; Andersen, Henning Boje; Jensen, Niels Steenfeldt; Klit, Peder; Wingstrand, Sara ; Hassager, Ole / **DTU's undersøgelser af lav adhæsion / glatte skinner for Transportministeriet og DSB.** Danmarks Tekniske Universitet (DTU), 2014. 568 p.

For an updated overview of our publications go to our website www.kt.dtu.dk

PUBLICATIONS CONTINUED

PhD Theses

CAPEC-PROCESS:

Babi, Deenesh K: **Sustainable process synthesis-intensification**

Baggesen, Claus: **A Study of microalgal symbiotic communities with the aim to increase biomass and biodiesel production**

Bodla, Vijaya K: **µ-structured devices as tools for screening process intensification in biocatalysis**

Krešimir, Janeš: **Applying enzymatic cascades for ISCPR in ω-transaminase systems**

Mattei, Michele: **Advances in Chemical Product Design: An Integrated Methodology for Emulsified Formulated Product Design**

Mitic, Aleksandar: **Operational Aspects of Continuous Pharmaceutical Production**.

Price, Jason: **Modelling and operation of reactors for enzymatic biodiesel production**

Ramesh, Hemalata: **Oxidase-based biocatalytic processes**

Yunus, Nor Alafiza: **Systematic methodology for design of tailor-made blended products: Fuels and other blended products**

AT CERE:

Arshad, Muhammad Waseem: **Measuring and thermodynamic modelling of de-mixing CO_2 capture systems**

Liang, Xiaodong: **Thermodynamic modeling of complex systems**

Maribo-Mogensen, Bjørn: **Development of an electrolyte CPA equation of state for applications in the petroleum and chemical industries**

BIOENG:

Ambye-Jensen, Morten: **Ensiling as preatreatment of grass for lignocellulosic biomass conversion**

Dominiak, Malgorzata Maria**: Substrate-based selection of enzymes**

Feng, Tao: **Substrate-based selection of enzymes**

Guo, Yao: **Enzymatic production of human milk oligosaccharides**

Larsen, Dorte Møller: **Engineering of pectinolytic enzymes for enhanced thermostability**

Lezyk, Mateusz: **Diversity screening for novel enzymes degrading synthetic polymers**

Michalak, Malwina: **Enzymatic production and purification of prebiotic oligossaccharides by chromatography and membrane systems**

Ravn, Helle C: **Engineering aspects of enzymatic fiber solubilization from potato pulp**

Thomsen, Sune T: **Bioenergy in Ghana - Biogas and ethanol from agricultural residues**

CHEC:

Hjorth, Jeppe Lindegaard: **Mathematical modeling of vegetable oil crystallization**

Maarup, Claus: **Gas-solid heat exchanger for cement production**

Mut, Maria del Mar Cortada: **Sulfur release during alternative fuels combustion in cement rotary kilns**

Mortensen, Peter Mølgaard: **Catalytic conversion of bio-oil to fuel for transportation**

Zhang, Shizhong: **Accelerated rain erosion of wind turbine blade coatings**

Nørgaard, Kristian Petersen: **Investigation of an intumescent coating System in pilot and laboratory-scale furnaces**

Pathi, Sharat: **CO_2 capture for cement technology**

Pedersen, Michael Jønch: **Design of continuous reactor systems for API production**

Saleh, Suriyati: **Torrefaction of biomass for power production**

Qin, Siqiang**: Foaming and foaming control in wet flue gas desulphurization plants: Laboratory- and pilot-scale investigations**

DPC:

Goswami, Kaustav: **Synthesis and characterizations of high permittivity ultraviolet cures soft elastomeric networks and composites applicable as dielectric electroactive polymer**

Ma, Baoguang: **Novel water shutoff treatment using PDMS elastomer**

Madsen, Frederikke B: **Synthetic strategies for high dielectric constant silicone elastomers**

Vudayagiri, Sindhu: **Large scale processing of dielectric electroactive polymers**

ECO:

Ingvordsen, Cathrine H: **Climate change effects to plant ecosystems - Genetic resources for future barley breeding**

INDUSTRIAL PHDS

NAME	PROFESSION	COMPANY
Albert Camós Noguer	Industrial PhD	Hempel A/S
Ane Høyer Mollerup	Industrial PhD	Københavns Energi A/S
Brian Pierce	Industrial PhD	Dupont A/S
Jakob Dragsbæk Duhn	Industrial PhD	Haldor Topsøe A/S
Jeppe Lindegaard Hjorth	Industrial PhD	Aarhus Karlshamn Denmark A/S
Kasper Linde	Industrial PhD	Haldor Topsøe A/S
Michael Jønch Pedersen	Industrial PhD	H. Lundbeck A/S
Morten Søe Jepsen	Industrial PhD	Vølund A/S
Pernille von Freisleben	Industrial PhD	Novozymes A/S
Thomas Petersen	Industrial PhD	GEA Process Engineering A/S

MSC, BSC AND BENG COURSES 1 OCTOBER 2013 - 30 SEPTEMBER 2014

The department participates in a 3½ year education for the Bachelor of Engineering, a 3 year education for Bachelor of Science and a 2 year education for the Master of Engineering. Below, course numbers and names are shown for 2014, with the number of students attending shown in brackets. Courses for Bachelor of Engineering are marked with **(B)**. The other courses are Bachelor of Science courses, Master of Science courses or common courses.

SPRING-SEMESTER

28001 Introduction to Chemistry and Chemical Engineering (68)
28016 Mathematical models for chemical and biochemical systems (14) **(B)**
28018 Chemical and Biochemical Process Engineering (57) **(B)**
28019 Chemical and Biochemical Process Engineering (16) **(B)**
28020 Introduction to Chemical and Biochemical Engineering (53)
28022 Unit Operations of Chemical Engineering and Biotechnology (21) **(B)**
28025 Bio Process Technology (43)
28121 Chemical Unit Operations Laboratory (22)
28124 Summer course in chemical process and plant design (41)
28157 Process Design (10) **(B)**
28160 Mathematical models for chemical systems (47)
28212 Polymer Chemistry (27)
28214 Polymer Synthesis and Characterization (8)
28221 Chemical Engineering Thermodynamics (12)
28231 Laboratory in Chemical and Biochemical Engineering (25)
28270 Industrial Ecology (18)
28271 Bioenergy and sustainability—recycling of ash fractions from thermal gasification (9)
28322 Chemical Engineering Thermodynamics (25) **(B)**
28342 Chemical Reaction Engineering (17) **(B)**
28345 Chemical Reaction Engineering (35)
28350 Process Design: Principles and Methods (37)
28352 Chemical Process Control (15) **(B)**
28415 Oil and Gas Production (55)
28423 Phase Equilibria for Separation Processes (34)
28434 Membrane Technology (61)
28443 Industrial Reaction Engineering (34)
28451 Optimizing Plantwide Control (29)
28850 Quality by Design (QbD): Integration of product and process development (29)
28852 Risk Assessment in Chemical Industry (23)
28855 Good Manufactoring Practice (64)
28864 Introduction to Matlab Programming (28)
28871 Production of Biofuels (26)
28885 Technology and Economy of Oil and Gas Production (45) **(B)**

Course given in co-operation with other departments:

26316 Analysis and Chromatography (46)
27944 Biotechnology and process design (16) **(B)**
41683 Materials Science (25) **(B)**

EDUCATION CONTINUED

MSC, BSC AND BENG COURSES

FALL-SEMESTER

28016 Mathematical models for chemical and biochemical systems (25) **(B)**
28018 Chemical and Biochemical Process Engineering (88) **(B)**
28022 Unit Operations of Chemical Engineering and Biotechnology (25) **(B)**
28121 Chemical Unit Operations Laboratory (38)
28140 Introduction to Chemical Reaction Engineering (26)
28150 Introduction to Process Control (23)
28157 Process and product design (24) **(B)**
28213 Polymer Technology (33)
28233 Recovery and Purification of Biological Products (43)
28242 Chemical Kinetics and Catalysis (41)
28244 Combustion and High Temperature Process (57)
28246 Applied Enzyme Technology and Kinetics (38)
28247 Advanced Enzyme Technology (7)
28272 Engineering and Environmental Sustainability (10)
28310 Chemical and Biochemical Product Design (42)
28315 Colloid and Surface Chemistry (72)
28316 Laboratory Course in Colloid and Surface Chemistry (16)
28322 Chemical Engineering Thermodynamics (19) **(B)**
28342 Chemical Reaction Engineering (27) **(B)**
28352 Chemical Process Control (19) **(B)**
28361 Chemical Engineering Model Analysis (44)
28420 Separation Processes (41)
28515 Enhanced Oil Recovery (26)
28530 Transport Processes (44)
28811 Polymers in Processes and Products (8)
28845 Chemical Reaction Engineering Laboratory (23)
28864 Introduction to Matlab Programming (33)
28870 Energy and Sustainability (77)
28872 Biorefinery (33)

Courses given in co-operation with other departments:

10336 Fundamentals Problems in Fluid Dynamics (12)
23522 Rheology of food and biological materials (11)
26010 Introductory Project in Chemistry (49)
26316 Analysis and Chromatography (46)
27004 Health, Diseases and Technology (61)
27944 Biotechnology and process design (20) **(B)**
41657 Materials Science for Chemists (46)
41683 Materials Science (221 **(B)**

MASTER OF SCIENCE DEGREES

54 students finished their research projects for the MSc Degree. The project titles and names of the students are listed below:

Andersen, Stinus Kappel
Sustainable biorefining of brown seaweed biomass: Pretreatment technology

Arndal, Trine Marie Hartmann
Kinetics of Methanol Synthesis at Low Operating Temperatures over a Cu-based Catalyst

Aweis, Mallak Stella
Pretreatment and combustion of biomass

Bagger, Niels Valdemar
Optimization of energy savings for the Novo Nordisk ethanol recovery process

Bertran, Maria-Ona
Chemical processing routes based on reaction pathways

Capellades Mendez, Gerard
Transition from batch to continuous crystallization in the pharmaceutical industry

Castillo, Haydee Garcia
Anticorrosive coatings and interlayer adhesion loss

Cignitti, Stefano
Computer-Aided Reaction Path Synthesis

Damborg, Rune Falck
Catalytic oxidation of CO and C_3H_6 under diesel exhaust conditions

Einarsve, Martin Jørgen
Numerical Modelling of Oil Production by Smart Waterflooding

Franco Garcia, Andreau-Maria
Fillers for antifouling coatings

Frauzem, Rebecca
Techno-economic evaluation of a CO_2-conversion process

Frederiksen, Lisbeth
Assessing potential of dynamic microfiltration for E. coli based systems, with a special focus on critical upstream separation and filtration elements

Gadsbøll, Rasmus Østergaard and Jesper Thomsen
Experimental analysis of a SOFC stack fueled by biomass gasification gas

Galvanin, Silvia
Study of the influence of reactor geometry on enzymatic reaction kinetics

Gonzales Martos, Luis
Polymers as Barrier Membranes in Pipelines for Supercritical CO_2 in Offshore Applications

Haastrup, Birgit
Application of enzymes for enhanced oil recovery

Hansen, Christian Houmann
Recovery and purification of product from reactor effluent

He, Boyang
Investigation of novel dispersing principles for the coatings industry

Hoffmann, Christian
Synthesis of functional polymers and preparation of functional thiol-epoxy hydrogels

Jacobsen, Casper Funk
Fluidized bed reaktor design for formaldehyde production

Jakobsen, Casper
Analysis of inhomogeneity and optimizing agitation/aeration of an industrial scale fermentation by applying computational fluid dynamics (CFD)

Jensen, Christina Maj
Optimizing enzymatic biodiesel production in a fed-batch process using high free fatty acid, high melting point feedstock

Jensen, Lars Lyskov
Conceptual Development of the Internal By-Pass Cooled Reactor

Jepsen, Morten Søe
Pyrolysis of Large Biomass Particles in a Single Particle Combustion Reactor

Jurgutis, Linas
Biogas production from ethanol fermentation residues and agricultural waste products in Ghana

EDUCATION CONTINUED

MASTER OF SCIENCE DEGREES CONTINUED

Kalinikos, Dimitrios
Displacement flow in non-uniform well bores

Kamstrup, Mette Hermann
Optimising rotational speed for mixing by rotary jet mixers

Larsen, Rene Jonsgaard
Regulation and simulation of the binder used in the granulation process in terms of particle size distribution

Lützen, Peter
Control Benchmark for Solvent Recovery Unit

Maimann, Michael
Optimization of enzyme cocktails for biomass with increased pectin content

Mar, Mette Dysseholm
Enzymatic hydrolysis of municipal solid waste

Martinéz San Segundo, Ignacio
Synthesis of Novel Alkyd Binders for Protective Wood Coatings from Bio-based Raw Materials

Mesker, Stephanie Victoria Odette
Optimization of energy rich processes in refining using KPI's

Milne, Douglas Allan Ross
An evaluation of the potential for injecting produced water to aid the artificial lift systems in offshore heavy oil production

Moldestad, Annette Pauline
Preparation and characterization of xyloglucan gels

Morthensen, Sofie Thage
Fouling behavior of case in glycomacropepetide (CGMP) in ultrafiltration

Møller, Caroline Gundorph
Sustainable Alternatives for the Production of Methylene Diphenyl Diisocyanate

Møller, Victor Buhl
Coatings for the cement and mineral industry

Nielsen, Anders Krebs
Modelling of soot oxidation in diesel particulate filters

Pachitsas, Stylianos
The effect of oil on hydrate formation in natural gas pipelines

Pedersen, Asbjørn Toftgaard
Kinetic characterization of HFCS dehydration

Perez Hornero, Clara
Design and construction of equipment for evaluation of coatings at extreme conditions

Prior, Rasmus Andreas
Evaluation of a bioprocess for thiamine production

Rasmussen, Simon Jacob
Low NOx Calciners for the Cement Industry

Reinoso Rodriguez, Rosa
Mechanical Properties and Heavy Duty Epoxy Coatings

Ring, Martin Patrick Beagan
Production of natural methane hydrate by CO_2 hydrate swapping

Rubin, Alexander
Design and optimization of a CO_2 conversion process

Rønnedal, Kristian
High-pressure oxidation of marine Diesel fuels

Saiz Perez, Cristina
Biorefining of hemp seeds: Enzyme assisted upgrading

Schlaikjer. Anders
Towards a predictive CPA equation of state for chemical applications

Storgaard, Thomas Busch
Preparation of functional linear polyesters by enzymatic polymerization of bio-based monomers

Wingstrand, Sara Lindeblad
Rheology of PMMA solutions

BACHELOR OF SCIENCE IN ENGINEERING DEGREES

26 students finished their research programme for the BEng and BSc degree.
The project titles and names of the students are listed below:

Boesen, Cecilie Ranum and Katrine Vestervang Riviere
Modeling, and simulation of CO_2 capture in aqueous glycinate

Bonde, Christian Loft
Leaching for Chalcopyrite as a part of Cu-Refinery

Bording, David Gottlied
Energy storage in phase change materials

Gilbert, Jan Andersen
Measurements and modelling of CO_2 gas compression relevant fluid properties containing impurities

Hansen, Marc Skov
Measurement and modelling of mercaptane-water interaction for the oil industry

Hillig, Jonas
Simulation and design of a heat-integrated separation module

Israelsen, Kasper Christian
Exploration of novel thermodynamic equilibrium shifting methods for biocatalytic processes

Jensen, Jacob Møller
Evaluation criteria for wastewater treatment plant performance evaluation

Khan, Imran and Abduallah Mohammad Sayed
Data Reconciliation for a DME Purification Plant

Larsen, Louis Wilhelm Øckenholt
Technical and economic analysis of standardising specifications for components in fresh water generators

Lundquist, Casper Wolf
Modeling, control and test of falling film evaporation

Lydom, Simon Ingvardt
Rate-based Distillation Modeling

Mortensen, Søren
Rare earth elements from minerals found in Greenland—processes and thermodynamics

Neerup, Randi and Linda Rose
Measurement and modeling of CO_2 solubility in amino acid salt solutions

Nielsen, Mette Joan
Evaluation of molecular simulation methods for thermodynamic equilibrium determination

Nielsen, Rasmus Dannefeldt and Morten Lund Rasmussen
Acceleration of hydroamination reaction

Nygaard, Christian Wolff
Operation of experimental distillation column

Olsson, Signe Lynge
Computational Fluid Dynamic (CFD) Simulation of porous materials

Pedersen, Patrick Nicklas
Mathematical Modelling of Fluid-bed Coating Process

Svith, Casper Stryhn
Investigation of new ceramic silicon carbide flat sheet membranes

Vestphael, Morten Skov
Modeling of the thermal conductivity of salt solutions

Xiao, Xiao
Heat conductivity of salt solutions

STAFF & COMMITEES

Advisory Board
Staff 2014
Student Committee
Industrial PhDs and Guests
The Faculty
Departmental Seminars 2014

ADVISORY BOARD

LARS BANG

GROUP SENIOR VICE PRESIDENT,
SUPPLY OPERATIONS & ENGINEERING, H. LUNDBECK A/S

"Scientific research at university level is a prerequisite for the development of Lundbeck's chemical activities in Denmark. We have had a beneficial partnership with DTU Chemical Engineering for several years, collaborating on PhD projects and recruiting several of the department's candidates. Furthermore, it has been a great advantage to be able to draw on the knowledge of DTU Chemical Engineering's scientific staff as advisors/consultants".

KIM PANDRUP CHRISTENSEN

CHIEF TECHNICAL OFFICER AT ORECO A/S

"The close cooperation with DTU Chemical Engineering has ensured significant results in lot of industries. Long-term focus on development and innovation is necessary to meet the ever-changing opportunities, rules, legislation and profitability demands that all industries are faced with. DTU Chemical Engineering ensures a high level of education, motivated candidates and industrial cooperation in important research projects that will lead to technologies of the future".

BJERNE CLAUSEN

PRESIDENT AND CEO
HALDOR TOPSØE A/S

"Working closely with the best research groups within the fields of our core competences is of major importance to Haldor Topsoe A/S. Our cooperation with DTU Chemical Engineering enables us to resolve research challenges beyond our competences and resources and is an important source of inspiration and knowledge for employees at Haldor Topsoe, benefiting their own and the company's development".

PEDER HOLK NIELSEN

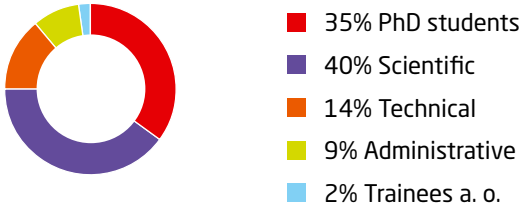
PRESIDENT & CEO
NOVOZYMES A/S

"At Novozymes we see innovation-driven partnerships as a key element in delivering tomorrow's solutions. At university level, we have had an exemplary cooperation with DTU Chemical Engineering for many years. This cooperation supports and complements our efforts in developing and testing new technologies, attracting new valuable employees and driving the world towards sustainability. DTU Chemical Engineering fully answers these demands".

STAFF 2014

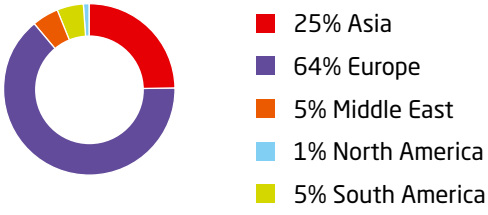
TYPE OF STAFF

(245 persons in total)



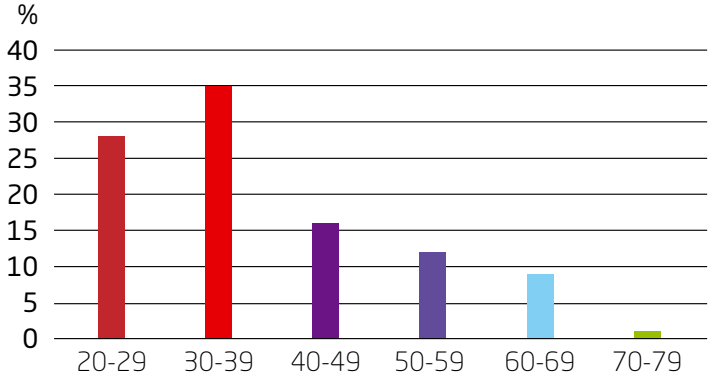
INTERNATIONAL SCIENTIFIC STAFF

(Total 105 persons)



STAFF DISTRIBUTED BY AGE

(Total 245 persons)



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Or go to our website: www.kt.dtu.dk

Scan the QR code to find names and contact information of our staff at DTU Chemical Engineering

STUDENT COMMITTEE

Our student organisation 'KTStudents' represents all students in the courses at the Department. For the benefit of all interested students to learn about their prospects as chemical engineers one day in the future, we organize many events such as:

- **Company Presentations** where companies are invited to present their work in order to give students a better understanding of the type of job challenges for chemical engineers in the companies.
- **Plant visits to company sites.** The companies typically have production or pilot facilities which give students an insight into of the real world of chemical and biochemical engineering.
- **Social Events** where we give students the opportunity to socialize and network with other students during an otherwise hectic semester. This is especially important for many students from abroad.

Liaison between the department and the students

In addition to learning what a career in chemical engineering entails, KTStudents also aims to help the academic development of chemical engineering students through being the liaison between the department and the students. Students can learn what opportunities there are in the Danish chemical industry, such as employment (both while studying and after), projects for special courses and industrial thesis topics. In addition, we aim to expose students to research undertaken at DTU Chemical and Biochemical Engineering to generate awareness about the research centres and to facilitate a direction for MSc or PhD thesis topics.

Murray Meissner, President
KTStudents

GUESTS

NAME	PROFESSION	FROM
Abderrahim Nouar	Visiting PhD student	Constantine Mentouri University, Algeria
Alejandro Mora Vazquez	Visiting MSc	Universidad Autonoma Metropolitana Azcapotzalco, Mexico
Alfonso Mauricio Sales-Cruz	Visiting Professor	Universidad Autonoma Metropolitana Unidad Cuasimalpa, Mexico
Ana Teresa de Melo Machado Simoes Carvalho	Visiting MSc	Universidade de Lisboa, Portugal
Anthony Vivion	Visiting MSc	ENSIACET, France
Arturo Pallares Garcia	Visiting MSc	Universidad Autonoma Metropolitana Azcapotzalco, Mexico
Bui Huu Tuan Nguyen	Guest MSc	Chulalongkorn University, Thailand
Carlos Eduardo Ramirez Castelan	Visiting MSc	Universidad Autonoma Metropolitana Azcapotzalco, Mexico
Emilie Paillot	Visiting BSc	National Polytechnic Institute of Chemical Engineering and Technology, France
Estelle Sonia Roas Garanhao	Visiting MSc	UTL, Portugal
Fabio Battini	Visiting PhD student	Pisa University, Italy
Felipe Fernando Furlan	Visiting PhD student	University sao Carlos University, Brazil
Flòra Màrta Kiss	Visiting MSc	Universitât des Saarlandes, Germany
Francios Vibert	Visiting MSc	ENSIACET, France
Francisco José Suné Grande	Visiting PhD student	University Rovira, Spain
Kosan Roh	Visiting PhD student	KAIST, South Korea
Leila Nemdili	Visiting PhD student	Constantine Mentouri University, Algeria
Li Yee Phoon	Visiting PhD student	UTM, Malaysia
Mafalda Costa Artur Dias	Visiting MSc	Universidade de Lisboa, Portugal
Maria Teresa Lopez-Arenas	Visiting Professor	Universidad Autonoma Metropolitana Unidad Cuasimalpa, Mexico
Masao Doi	Visiting Professor	Beihang University, China
Perapong Supawanich	Guest MSc	Chulalongkorn University, Thailand
Ryoichi Nakayma	Visiting PhD student	Nihon University, Japan
Sebastian Mayer	Visiting MSc	TU München, Germeny
Sun Hyung Kim	Visiting Postdoc	Korea University, Korea
Tannaz Tajsoleiman	Visiting MSc	Sharif University, Iran
Worawit Peng-noo	Guest MSc	Chulalongkorn University, Thailand
Yohann le Guennec	Visiting MSc	Ensic. inpl-nancy, France
Yu Song	Visiting PhD student	Huazhong University of Science and Technology - China
Zhimin Lu	Visiting Professor	South China University of Technology, China
Zhiya Duan	Visiting BSc	National Polytechnic Institute of Chemical Engineering and Technology, France

THE FACULTY **2014**

Jens Abildskov
Associate Professor

Per Ambus
Professor
(Resigned 1 December 2014)

Jakob Munkholt Christensen
Assistant Professor

Karsten H. Clement
Professor (Docent)

Kim Dam-Johansen
Professor,
Head of Dept.

Anders Egede Daugaard
Associate Professor

Philip Fosbøll
Assistant Professor

Rafiqul Gani
Professor

Krist V. B. Gernaey
Professor

Peter Glarborg
Professor

Ole Hassager
Professor

Søren Hvilsted
Professor (Research manager)

Jakob Kjøbsted Huusom
Associate Professor

Andreas Ibrom
Senior Scientist

Anker D. Jensen
Professor

Søren Kiil
Associate Professor

Georgios M. Kontogeorgis
Professor

Ulrich Krühne
Associate Professor

Anne Meyer
Professor

Jørn Dalgaard Mikkelsen
Professor

Teis Nørgaard Mikkelsen
Senior Scientist

Kim Pilegaard
Professor

Manuel Pinelo
Associate Professor

Alexander A. Shapiro
Associate Professor

Gürkan Sin
Associate Professor

Anne Ladegaard Skov
Associate Professor

Nicolas Von Solms
Associate Professor

Peter Szabo
Associate Professor

Kaj Thomsen
Associate Professor

Stig Wedel
Associate Professor

John Woodley
Professor

Hanne Østergård
Research Specialist

Lars Georg Kiørboe
Technical Manager

Gitte Brandt
Head of Secretariat

Gunnar Jonsson
Associate Professor Emeritus

Sten Bay Jørgensen
Professor Emeritus

Michael L. Michelsen
Professor Emeritus (Docent)

John Villadsen
Professor Emeritus

DEPARTMENTAL SEMINARS AT DTU CHEMICAL ENGINEERING IN 2014

11 MARCH

Professor Gerald Pollack, University of Washington, USA

"The Fourth Phase of Water: Beyond Solid, Liquid, and Vapor"

20 MARCH

Professor Masao Doi, Center of Soft Matter Physics and Its Applications, Beihang University, China

"Drying Dynamics of Polymer Solutions"

22 MAY

Dr. Christian Catry, Senior Scientist, Pharmaceutical Development & Manufacturing Sciences, Janssen Pharmaceutica, Belgium.

"From a molecule to a medicine. An introduction of the development process within Johnson & Johnson"

20 JUNE

Professor Manuel Pinelo, DTU Chemical Engineering, Denmark

"Unraveling the common misunderstandings about Membrane Technology"

2 SEPTEMBER

Visiting Professor Konstantinos Panayiotou, Department of Chemical Engineering, Aristotle University of Thessaloniki, Greece

"From Metabolic Pathways to Tissue Engineering: A Journey with Molecular Thermodynamics"

11 SEPTEMBER

Professor Ignacio E. Grossmann, Carnegie Mellon University, USA

"The Role of Process Systems Engineering in Chemical Engineering"

18 SEPTEMBER

Professor Herbert Shea, École Polytechnique Fédérale de Lausanne, Switzerland

"Miniaturized Dielectric Elastomer Actuators: Towards Intelligent Soft Machines"

24 OCTOBER

Professor Frans Muller, Department of Chemistry, Leeds University, UK

"Once through continuous slurry hydrogenations"

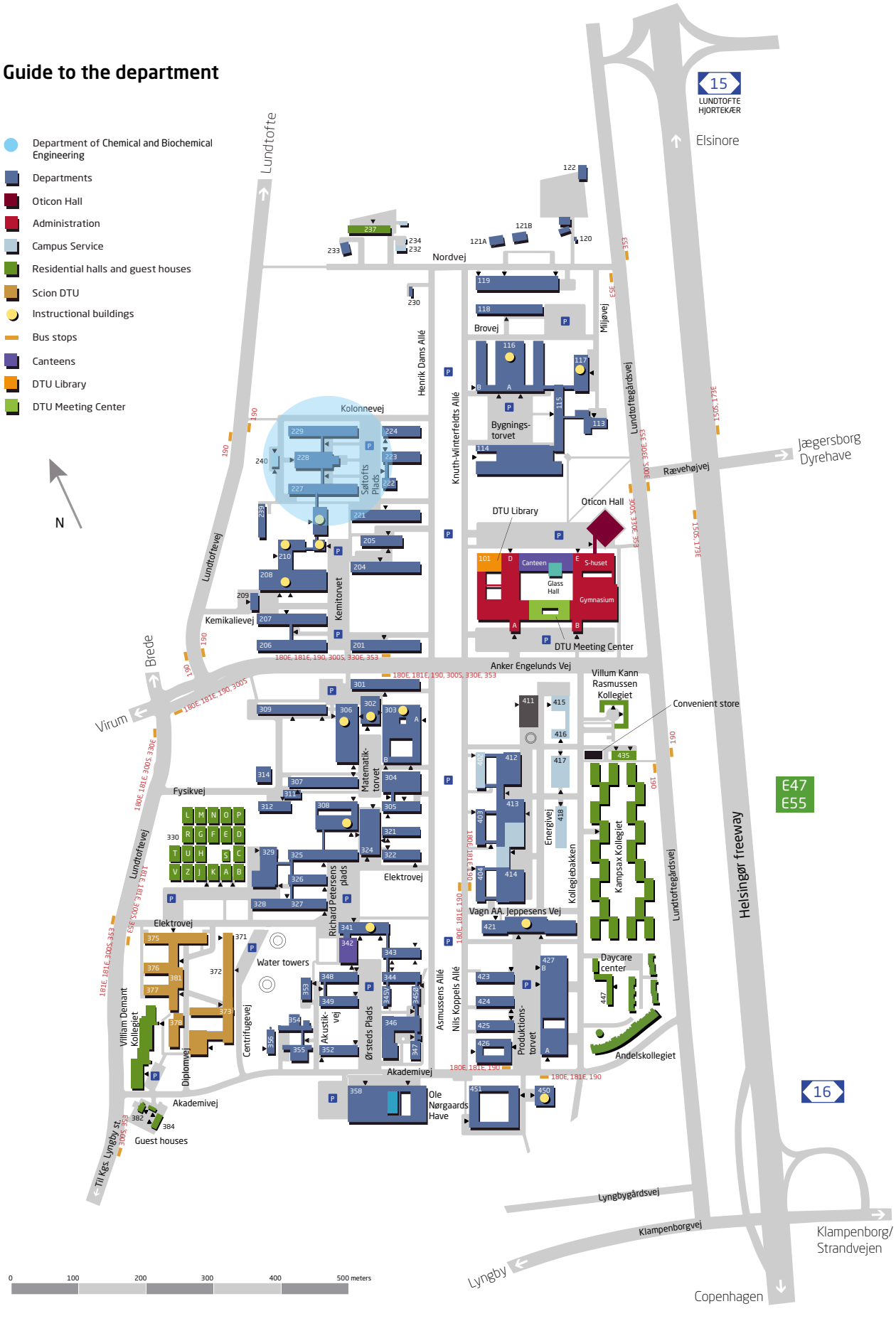
19 NOVEMBER

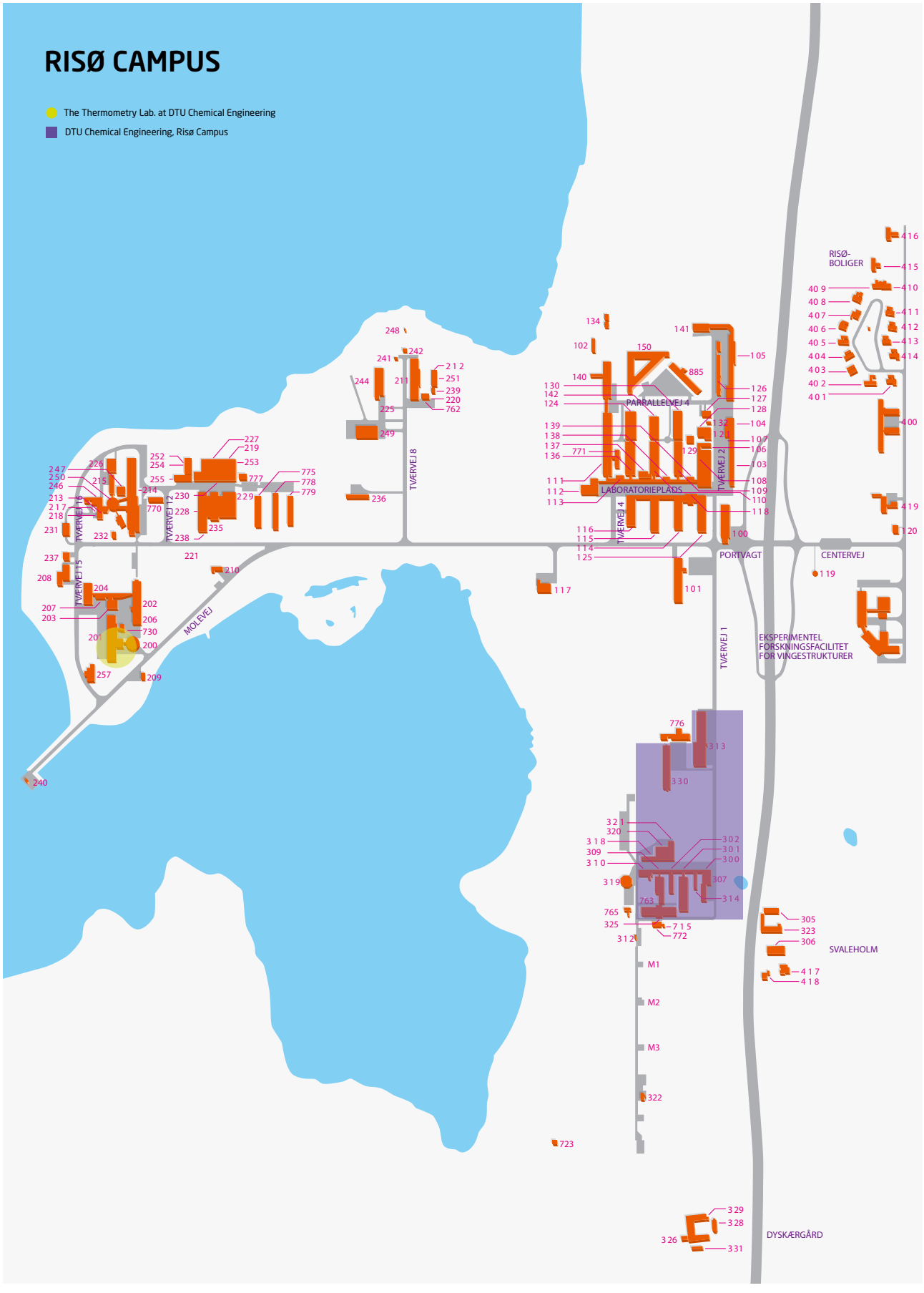
Professor Philip Fosbøl, DTU Chemical Engineering, Denmark

"The misconception of CO_2 – care less, influence more"

USEFUL INFORMATION

Guide to the department




RISØ CAMPUS
The Thermometry Lab. at DTU Chemical Engineering
DTU Chemical Engineering, Risø Campus
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LABORATORIEPLADS
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CENTERVEJ
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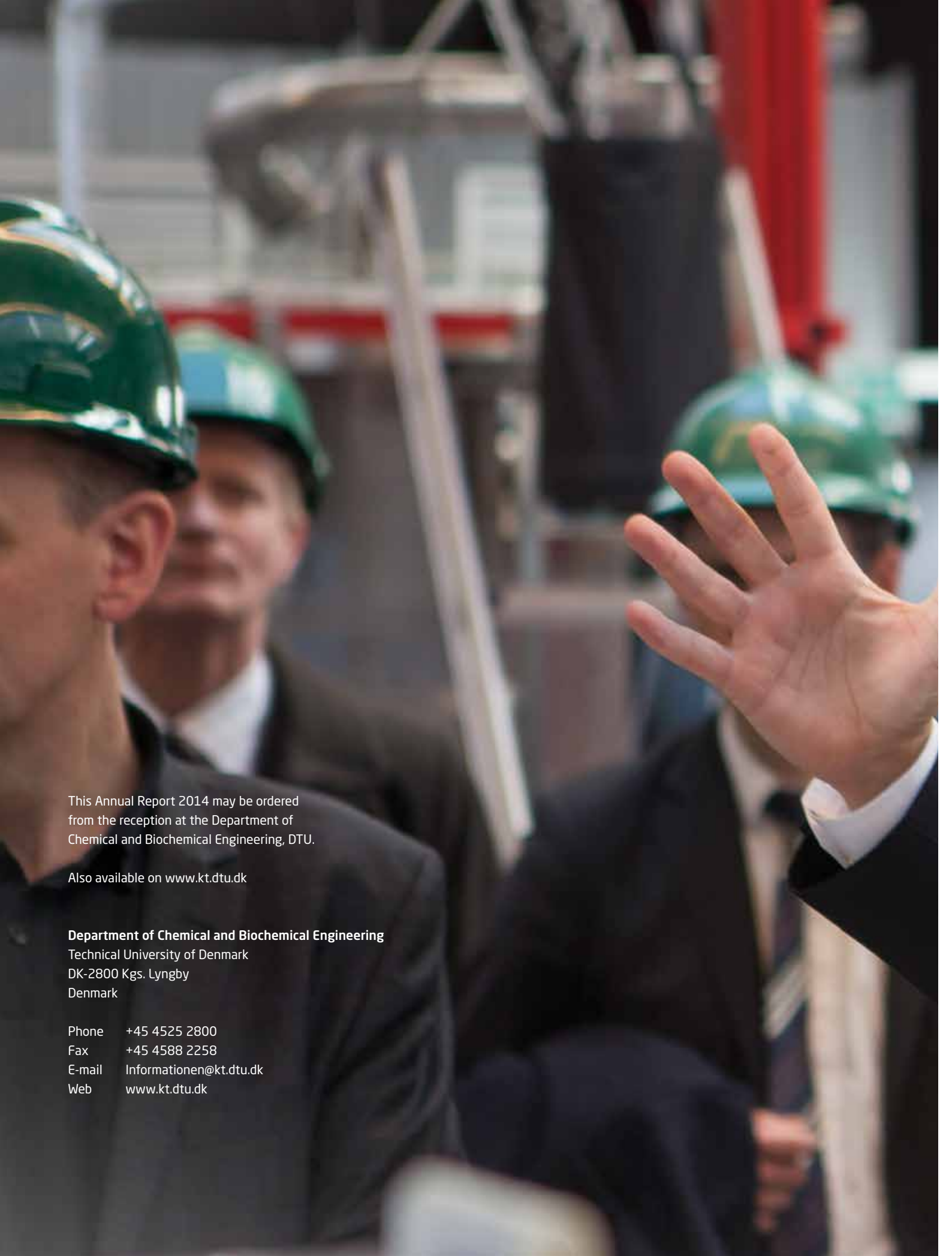

This Annual Report 2014 may be ordered from the reception at the Department of Chemical and Biochemical Engineering, DTU.

Also available on www.kt.dtu.dk

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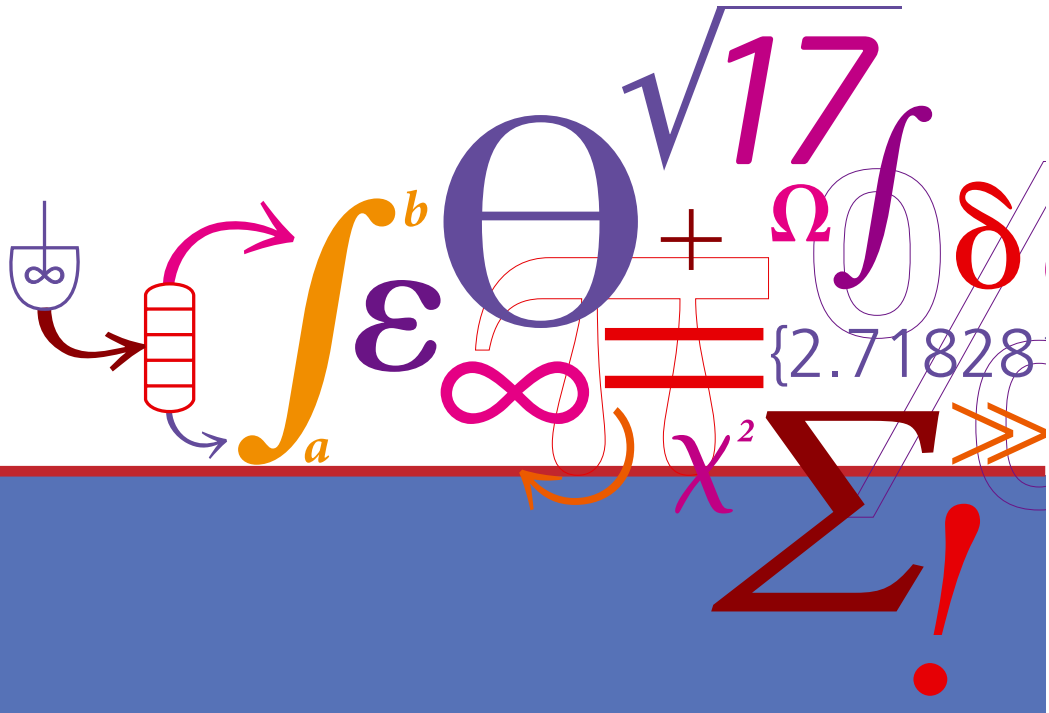
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