NTNU

DEPARTMENT OF ENERGY AND PROCESS ENGINEERING

ANNUAL REPORT 2019

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Researcher Kathrin Weber (SINTEF) and Terese Løvås, Head of Department of Energy and Process Engineering (NTNU) with biochar in front of one of the two newly planted city trees on Øya in Trondheim. The tree planting is part of the project ABC4soil, with the following partners: NTNU, SINTEF, RWTH Aachen University in Germany, Geisenheim University in Germany and Ithaka Institute in Switzerland. Photo: Maren Agdestein

LOOKING BACK AT 2019

The Department of Energy and Process Engineering is one of the largest of the 55 departments at NTNU, and one of 8 at the Faculty of Engineering. Our research is within a wide range of areas covering sustainable energy production and energy-efficient processes, as well their environmental impact within the framework of industrial ecology.

EPT shares the mission that, as part of a university, we have responsibility for conducting high quality research and for educating outstanding graduates. EPT has a strong profile towards science and technology development within the energy and process sector. Furthermore, EPT's mission is to contribute to Norway's role in developing a sustainable foundation for society on the regional, national and global level.

2019 was yet another successful year in securing funding for groundbreaking research, from both national and international funding bodies. We are very proud that EPT now has two ERC starting grants active at the department. Also, our professors' important contribution to the IPCC reports on climate change, its implications and potential future risks has received international acknowledgement. In this report we present the highlights of the wide range of activities that has kept us extremely busy in the last year.

It is important for us to ensure that our graduates are ready to meet the societal and industrial challenges of the future. As a Department we are involved in a large portfolio of study programmes at the Faculty of Engineering, as documented in this report. In 2019 the Bachelor programmes were reaccredited after the merger with the university colleges, and as a result we now have students at all three campuses in Trondheim, Gjøvik and Ålesund.

I would like to thank all our employees for their continued effort to ensure that EPT is still growing on all important key performance factors. I hope that this annual report brings back good memories of proud moments in 2019. I would also like to take this opportunity to thank all our research partners on the many ongoing and new projects. We look forward to continuing this path in 2020!

THE ENERGY LANDSCAPE

The Energy Landscape spans the entire scope of energy research and competence building conducted at SINTEF Energy and the Department of Energy and Process Engineering.

Illustration: SINTEF/NTNU/Oxygen

VERONES WILL

MAP

HOW HUMANS AFFECT THE OCEAN

By Anne Sliper Midling and Maren Agdestein

"I think green innovation will be a competitive advantage for companies going forward," says Professor Francesca Verones. She was awarded a grant of EUR 1 million from the European Research Council (ERC) to figure out how humans affect the oceans. Photo: Maren Agdestein.

Francesca Verones has been awarded a prestigious grant of EUR 1 million by the European Research Council to study how people affect the oceans.

"This is fantastic news," says a proud Terese Løvås, Head of Department at EPT.

"First of all, to win an ERC Starting Grant is internationally prestigious both for a researcher and for NTNU. Secondly, it is usually theoretical basic research that receives these grants," she points out.

"This is a thematic area with a strong environmental profile, which is very up-to-date with all the challenges we see with pollution in the sea."

A TOOL FOR BUSINESSES AND POLICYMAKERS

Verones' first task with the ERC Grant is to map everything from shipping routes, how the ships are built, how all the world's countries handle everything from trash to tourism. Finally, she will assess how these factors and many others all affect the oceans. Once she has put together the pieces of this giant puzzle, it could provide a tool for businesses, governments and the EU.

"Let's say Apple is going to create a new phone. They have to make a lot of choices for materials, packaging and shipping. Let's assume that we find ships to be the most environmentally friendly transport option, but that the choice of route is important. Then governments and the EU can come up with appropriate shipping regulations, for example. This kind of holistic knowledge is what I can help provide," Verones says.

"A BRILLIANT YOUNG SCHOLAR"

In her nomination for the 2019 Laudise Medal, her PhD advisor Stefanie Hellweg describes Francesca as "a brilliant young scholar who is pioneering the assessment of biodiversity effects in Life Cycle Assessment." Verones was awarded the Laudise Medal for outstanding achievements in industrial ecology by a researcher under the age of 36. The medal is awarded every second year by the International Society for Industrial Ecology.

Verones is now in the exclusive club of ERC grant holders at NTNU, along with Edvard and May-Britt Moser, EPT's Nicholas Worth, and a few others.

Tonnes of plastic waste end up in the sea every minute. The new EU research grant will help us better understand how plastic can affect entire marine ecosystems.
Photo: Colourbox.

WHAT IS THE ROLE OF THE

ENERGY SYSTEM

IN THE TRANSITION TO THE ZERO-EMISSION SOCIETY?

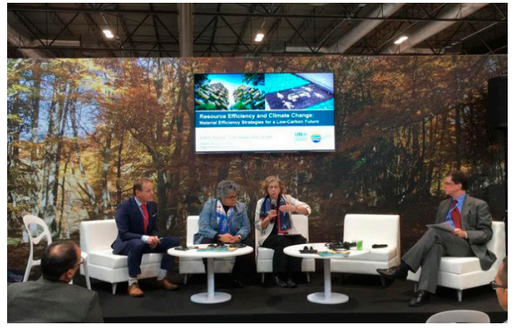
Professor Anders Hammer Strømman and Professor Edgar Hertwich contribute to the Norwegian Centre for Energy Transition Strategies (FME NTRANS), which is one of two new research centres for environmentally friendly energy (FME) announced by the Norwegian Research Council.

"The centre is an important complement to the technology-heavy research. We will look at the major lines in society for how to achieve the transition," says Anders Hammer Strømman.

At NTNU, the Faculty of Humanities hosts FME NTRANS. The work in the new centre is based on FME CenSes, (Centre for Sustainable Energy Studies), which was completed in 2019.

"We look forward to working with many interesting partners," says Professor Edgar Hertwich, who has rejoined NTNU as International Chair in Industrial Ecology after a stay at Yale University.

"While our colleagues in the new research centre work with the many technology pieces in the puzzle on how society should be restructured to achieve the climate goals, we will put the big puzzle together in the environmental accounts," says Professor Anders Hammer Strømman (to the right). Photo: Maren Agdestein



RESOURCES AND CLIMATE AT COP25 IN MADRID

What connections are there between resources and climate? The International Resource Panel (IRP) presented new work at the UN Climate Change Conference COP25 in Madrid. Lead author of IPCC Edgar Hertwich together with IRP Co-Chair Izabella Teixeira presented the results of this work at five side events.

Emissions from material production: Aluminium, steel and other metals are more carbon-intensive than other materials such as cement and plastics, according to the work by the International Resource Panel (IRP). Edgar Hertwich to the left. Photo: IRP.

OFFICIAL OPENING OF THE LOWEMISSION RESEARCH CENTRE

The LowEmission Research Centre officially opened in June 2019 and will develop new technologies and concepts for offshore energy systems, energy efficiency and integration with renewable power production technologies for application on the Norwegian Continental Shelf (NCS).

In addition to oil and gas operators, an impressive group of experienced and innovative vendors are partners in the centre and will actively work together with SINTEF and NTNU researchers. Professor James Dawson is Chair of the Scientific Committee and member of the Central Management Team, and Associate Professor Nicholas Worth leads the centre's research package on carbon-free firing of gas turbines. Other EPT researchers involved are Associate Professor Jonas Moeck, Professor Terese Løvås, Adjunct Professor Andrea Gruber and Associate Professor Lars Nord.

Kjell-Børge Freiberg, Minister of Petroleum and Energy, officially opened the LowEmission Research Centre on Friday 14 June. After the opening the Minister with company visited our laboratories in Kolbjørn Hejes vei 1. Photo: Lars R. Bang.

CHERUBINI HANDS OVER

IPCC REPORT

TO CLIMATE AND ENVIRONMENT MINISTER

By Nancy Bazilchuk

Combatting global warming will require major changes in land use, says a new climate change report from the Intergovernmental Panel on Climate Change (IPCC). One important change could be decreasing the amount of land used to produce livestock — which means that people would have to eat less meat.

Professor Francesco Cherubini was one of the lead authors of the IPCC's new special report, released in August, on Climate Change and Land, and was the only author from a Norwegian-based institution. He formally handed the report to Ellen Hambro, Director General of the Norwegian Environment Agency, and Ola Elvestuen, Minister of Climate and Environment on Thursday, 8 August when the IPCC released the report.

Ola Elvestuen, Minister of Climate and Environment (to the left), has just been handed the IPCC report by Professor Francesco Cherubini. Photo: Norwegian Environment Agency

"We need to produce more with less so that land is available for other uses," Cherubini said. "What is clear, is that we need to change. We need cross-sectoral changes in our lifestyles and in our economies."

One aspect of the new report that has generated the most attention is the suggestion that societies move to more vegetarian diets. Cherubini says it's clear that societies need to embrace this kind of change, along with improving and intensifying agricultural production.

Although these changes will cost money, the IPCC report emphasizes that the costs of inaction will exceed the costs of immediate action in many areas. That means that money spent now can be seen as a sound investment, he said.

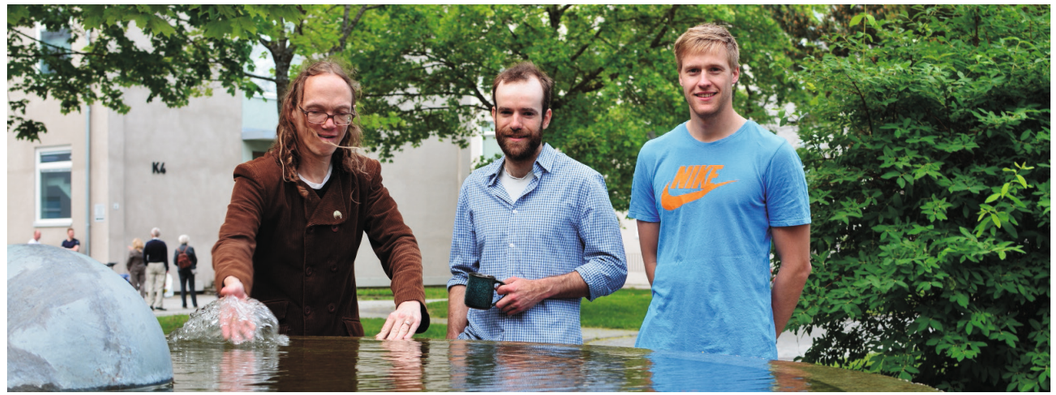
Grazing is by far the largest single type of land use affecting the planet, the new IPCC report says. The impact that producing livestock is even greater when you consider that half of all cropland is used to produce feed for animals. Photo: Colourbox

ELLINGSEN PREDICTED

SKEWED WAVES

– AND FOUND THEM

By Steinar Brandslet and Maren Agdestein



Professor Simen Andreas Ådnøy Ellingsen, PhD Candidates Benjamin Keeler Smetzer and Eirik Æsøy found the waves they were looking for. Photo: Lars R. Bang.

Simen Ådnøy Ellingsen solved a 127-year-old physics problem on paper and proved that off-centred boat wakes could exist. Five years later, practical experiments proved him right.

"Seeing the pictures appear on the computer screen was the best day at work I've ever had," said Simen Ådnøy Ellingsen, Professor at NTNU's Department of Energy and Process Engineering, to Norwegian SciTech News.

That was the day that PhD candidate Benjamin Keeler Smeltzer and master's student Eirik Æsøy had shown in the lab that Ellingsen was right and sent him the photos from the experiment. Five years ago, Ellingsen had challenged accepted knowledge from 1887, armed with a pen and paper, and won.

THE YOUNG ACADEMY OF NORWAY CHOSE ELLINGSEN

The Young Academy of Norway ("Akademiet for yngre forskere" in Norwegian) accepted twelve new members this year. One of the two chosen from NTNU is Simen Åndøy Ellingsen. The Young Academy of Norway is an interdisciplinary organization for young researchers dedicated to research policy and dissemination.

Fluid mechanics is at the heart of the most challenging climate issues, states Professor James Dawson. Photo: Maren Agdestein

Professor James Dawson, Deputy Head of Research at EPT, finds it encouraging to see that the engineering sciences, and especially fluid mechanics, are represented in the Academy of Young Scientists.

"Many people don't realise that fluid mechanics is at the heart of many of the most challenging climate issues as they underpin most energy and transport as well as climate modelling. It is important that talented young scientists interested in fundamental research are engaged with and listened to in order to help solve problems important to society. Politicians tend to think in the short term, while the challenges we face today must be met by the scientific understanding needed to develop the technologies needed to deliver the green transition and not volatile political agendas," Dawson says.

Bjarne Anton Foss, Prorector for Research, signed the Memorandum of Understanding together with representatives from Amity University. EPT's Trygve Eikevik is second from the right. Photo: NTNU

FOOD COOLING PROJECT PAVED THE WAY FOR COOPERATION AGREEMENT WITH INDIAN UNIVERSITY

In connection with a research project on food cooling in India, NTNU has signed a cooperation agreement with Amity University in India.

"We look forward to the research and education cooperation with Amity University," says Professor Trygve Eikevik, who is involved in the project. Re-FOOD will improve the cooling chain for food in India, and the project is coordinated by SINTEF Ocean. At NTNU, the Department of Biotechnology and Food Science is involved in addition to EPT.

NTNU TEAM HYDROGEN: THE 5 W'S

WHO AND WHAT

A team of hydrogen experts at NTNU from different disciplines, departments and faculties. The team is led by Professor Bruno G. Pollet.

WHEN AND WHERE

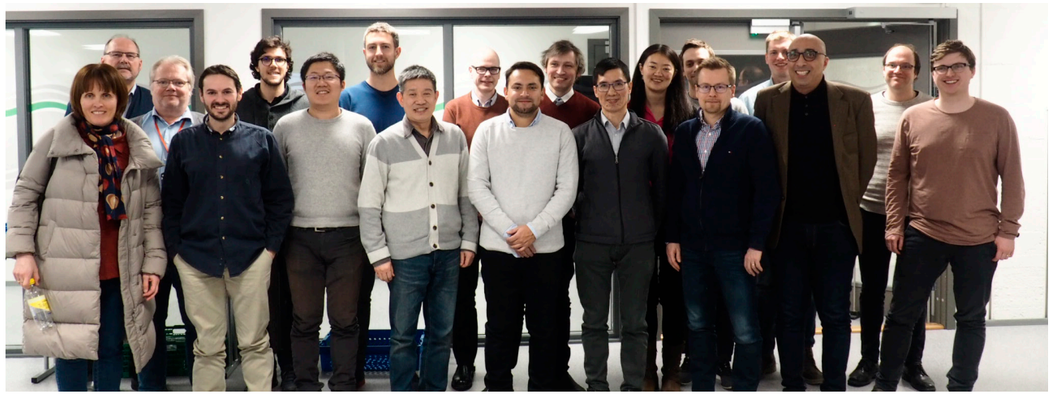
NTNU Team Hydrogen was founded in Trondheim at NTNU in 2019, and the work is conducted in the respective offices, labs and teaching areas of the hydrogen experts all over our university.

WHY AND HOW

One of the main tasks of the team is to develop new research programmes and projects both nationally and internationally with academia, research organizations and industry, and to coordinate hydrogen activities within NTNU. The team are also educating and training research leaders, innovating, providing solutions, and stimulating industry.

The team came about as part of the NTNU Energy strategy to assemble teams within certain areas such as hydrogen, battery, energy transition and wind.

See NTNU Team Hydrogen's projects, publications and events on their web pages: *www.ntnu.edu/energy/hydrogen*



The team in 2019. Photo: Pia Kristin Østeraas.

THE NEW OPERATION ROOM

LABORATORY

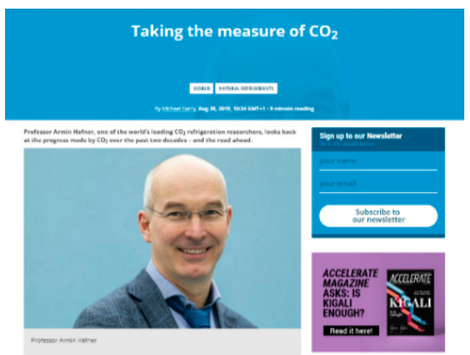
(OR LAB) CREATES NEW RESEARCH OPPORTUNITIES

The new Operation Room Laboratory (OR lab) was opened in Kolbjørn Hejes vei 1A, by Jan Gunnar Skogås, who heads the Operating Room of the Future project, and Trygve Eikevik, Deputy Head of Education at EPT.

"Our lab will give more opportunities to find effective indoor climate measures, and make the patients safer by finding the most optimal indoor climate," said Professor Guangyu Cao, Head of the new OR lab. The laboratory will also be used to make operation rooms more energy effective. Jan Gunnar Skogås underlined the benefits of having test facilities that are not needed for actual patients and doctors.

Operating Room of the Future is a cooperation between St. Olavs Hospital Trust and NTNU, as illustrated when Eikevik (NTNU) and Skogås (St. Olavs) cut the ribbon together.
Photo: Maren Agdestein

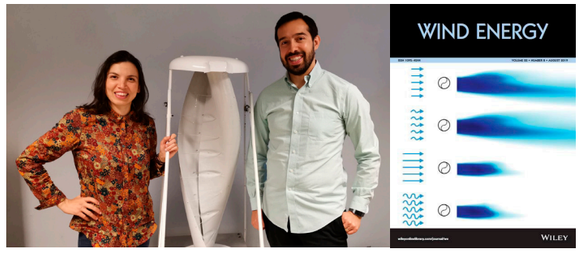
FACES IN PLACES



WORLD-LEADING REFRIGERATION EXPERT

In an in-depth interview in the refrigeration magazine R774.com, Professor Armin Hafner was interviewed about the progress made by CO2 over the past two decades. The article opens with a gratifying tribute: "Professor Hafner, one of the world's leading CO_2 refrigeration researchers".

Screenshot from R774.com



HEARST AND BRACCHI ARTICLE FEATURED IN WIND ENERGY

An issue of the level 2 journal "Wind Energy" features an article co-authored by Tania Bracchi and Jason Hearst, both Associate Professors at EPT.

Photo: Tania Bracchi and Jason Hearst with a Savonius vertical-axis wind turbine, the topic of the article in question. Photo: Maren Agdestein

HeatToH$_2$ cover story OF ENERGIES

Kjersti Wergeland Krakhella (to the right), Robert Bock, Odne Stokke Burheim (to the left), Frode Seland and Kristian Etienne Einarsrud demonstrating hydrogen production from heat
at 50°C.

Photo: Lars R. Bang

ON THE INSIDE

MEASUREMENTS OF OUR INDOOR ENVIRONMENT

As part of her doctoral project, Maria Justo Alonso made measurements of the indoor environment in EPTGym and in an office in Kolbjørn Hejes v 1B.

"If we can adapt ventilation properly to purpose and use, it is possible to save energy and help people work better," says Maria. Her PhD project is part of FME ZEN and her main supervisor is Professor Hans Martin Mathisen.

Photo: Maren Agdestein

INDECOL MOVED TO REALFAGSBYGGET

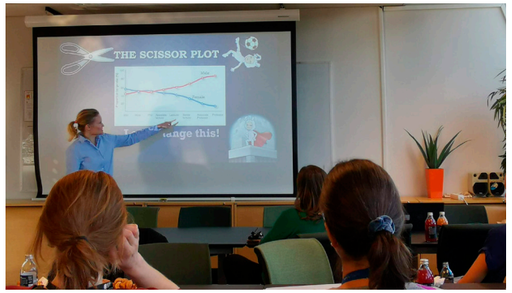
The academic community of the Industrial Ecology Programme moved this year.

"We are very pleased to have the opportunity to gather the students in approximately the same area that the academic staff will sit in. This will create a better sense of community, as well as greater proximity to supervisors and teachers," explains Head of Department Terese Løvås.

Photo: Philomena Chu.

EPT MOMENTS FROM

2019



“We must all act proactively to change ‘the scissor plot”, a term describing the phenomenon with fewer women in academic positions the higher up in the hierarchy”, said researcher Helene Muri at a local Women in Science initiative at EPT.

Photo: Maren Agdestein

Professor James Dawson held a keynote at the TCCS 10 conference organized by NCCS and hosted jointly by SINTEF and NTNU, where about 400 experts on carbon capture and storage meet annually in Trondheim.

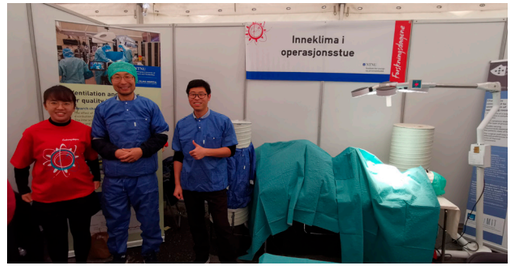
Photo: SINTEF

Engaged greetings from the HydroFlex workshop in May,.A project where the overall aims are breakthroughs to enable hydropower to operate with very high flexibility in order to utilize the full power and storage capability.

Photo: Lars R. Bang

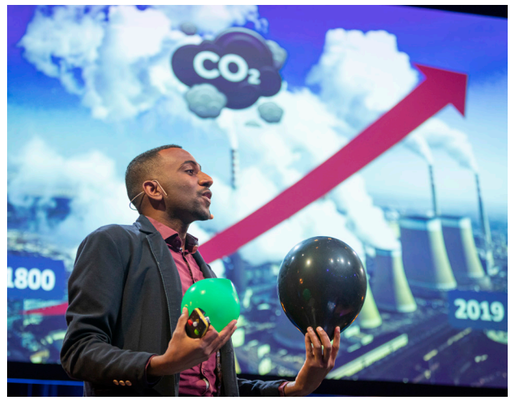
Sustainable research presented to the people of Trondheim: The exhibition FUTURUM, a free part of the Big Challenge science festival, was located near the city centre. Both industrial ecology and hydropower research at EPT presented their stands.

Photo: Smørekoppen (to the left) and Lars R. Bang (to the right)



3000 children, parents and teachers visited the annual “Forskningstorget”
(“Researcher’s Square”) including EPT’s stands where you could learn about dancing droplets and the indoor climate in operation rooms. Photo above left, from the left: Yixian Chang, Professor Guangyu Cao, Kai Xue. Photo above right, from the left:
Professor Carlos Dorao and Professor Maria Fernandino.

Photos: Maren Agdestein



Competed in Researcher Grand Prix:
PhD Candidate Mogahid Osman presented electricity and hydrogen production with zero CO_2 emission at the annual science communication competition.

Photo: Thor Nielsen/NTNU

EPT TRAINING AND SOCIAL

2019

EPTraining is great for meeting up and having fun with colleagues while training and staying healthy! During winter time we have ski training sessions, which are very popular. Running sessions, the St. Olavsloppet relay race from Trondheim to Östersund in Sweden and kayak courses keep us active in the summer. Weekly yoga was a new activity in 2019. All year round we have strength training in the EPTGym, where we also have a climbing wall.

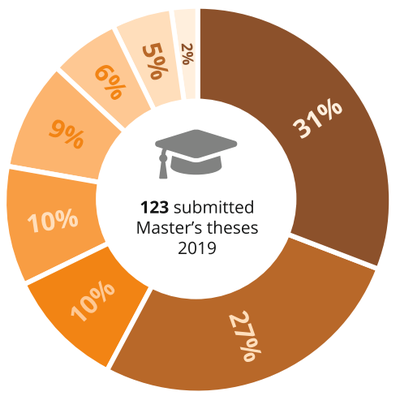
ST. OLAVSLOPPET

YOGA COURSE

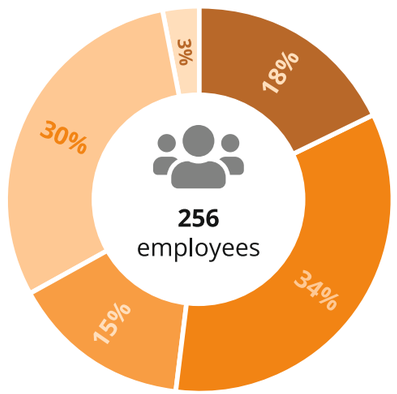
SKIING COURSE

KAYAK COURSE

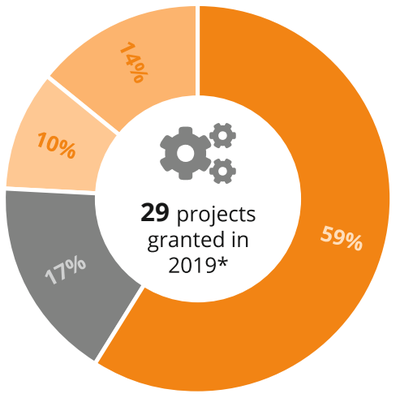
2019 IN NUMBERS



- Energy and Environmental Engineering (5 yrs)
- Mechanical Engineering (5 yrs)
- Energy Use and Energy planning (2 yrs)
- Industrial Ecology (2 yrs)
- Mechanical Engineering (2 yrs)
- Exchange students
- Natural Gas Technology (2 yrs)
- Innovative Sustainable Energy Engineering (2 yrs)



- Professors and Associate Professors
- PhDs
- Admin. and tech. staff
- Other researchers (adjunct professors, researchers postdoctors, researtch assistants)
- Others (HydroCen, ECCSEL, TSO)



- EU
- Research Council of Norway (RCN)
- FRIPRO (RCN)
- Others

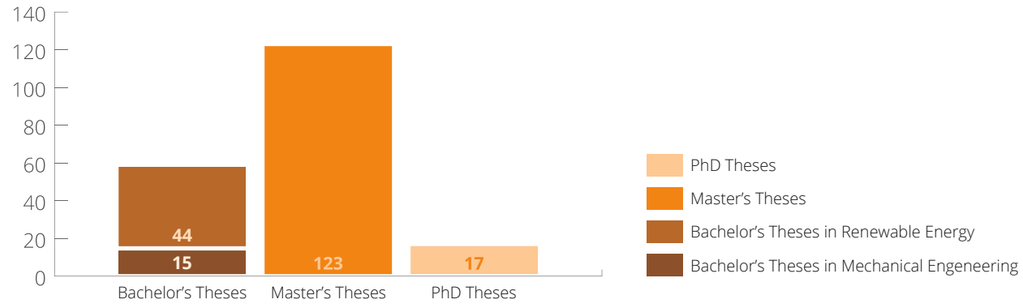
**Subject to project approvals that may be received after Jan. 2020*

63 APPLICATIONS TO THE RESEARCH COUNCIL OF NORWAY IN 2019 (2018: 79)

25 HORIZON 2020 PROGRAMME APPLICATIONS IN 2019 (2018: 23)

50 OTHER APPLICATIONS (EIT, EEA, ETC.)

SUBMITTED THESES

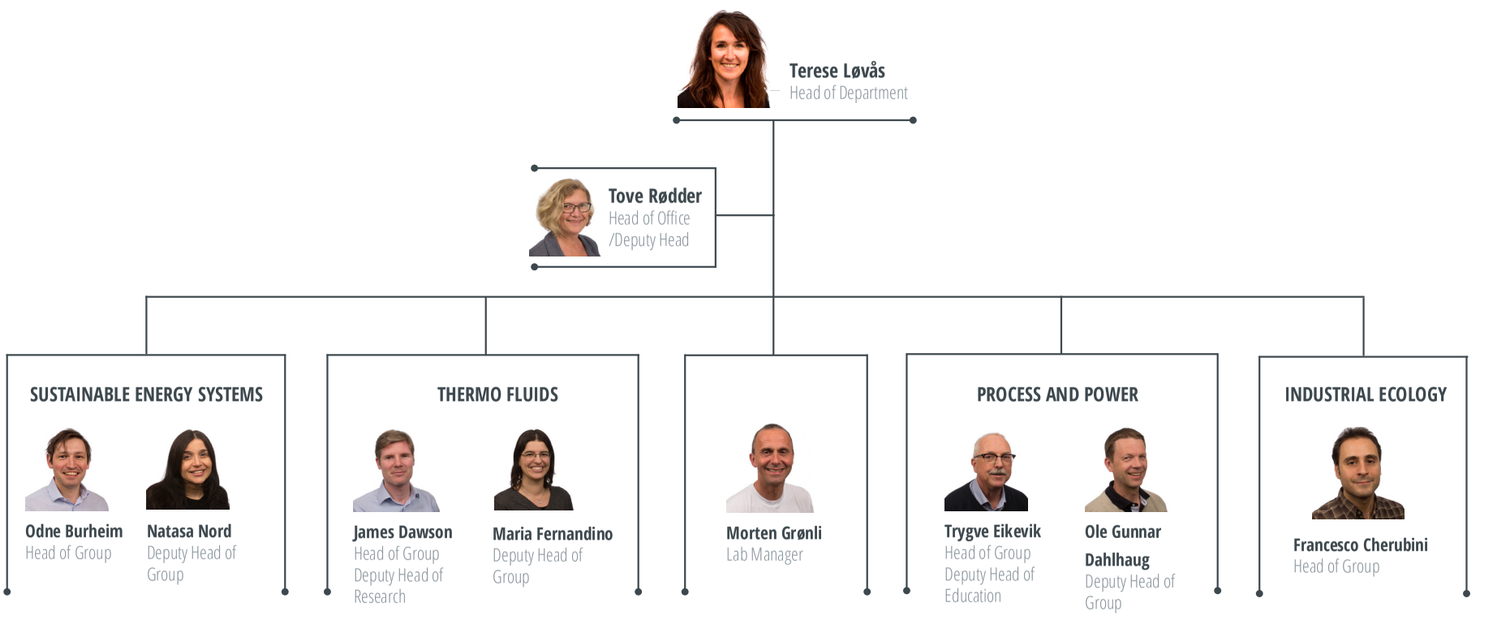


SUBMITTED PHD THESES

Name	Title of thesis	Supervisor	Research group
Aganovic, Amar	Airflow distribution for minimizing human exposure to airborne contaminants in healthcare facilities	Guangyu Cao,	Sustainable Energy Systems (SES)
Agnalt, Einar	Rotor Stator Interaction in low specific speed Francis Turbines	Dahlhaug, Ole G	Processes and Power (PP)
Auliano, Manuel	Controlling droplet cooling with micro/nano-structured surfaces	Dorao, Carlos	Thermo Fluids (TF)
Aursand, Eskil	Film boiling and LNG rapid phase transition	Müller, Bernhard	TF
Bakken, Martin	Transient analysis of wet gas compression systems	Bjørge, Tor (Equinor)	TF
Bergan, Carl	Dynamic Loads on Francis turbines: An Experimental Study	Dahlhaug, Ole G	PP
Clauss, John	Energy flexibility of Norwegian residential buildings using demand response of electricity-based heating systems	Georges, Laurent	SES
Dorber, Martin	Quantifying biodiversity impacts of hydropower electricity production within the framework of Life Cycle Assessment	Verones, Francesca	Industrial Ecology (IndEcol)
Kim, Donghoi	Evaluation and Optimization of Processes for Liquefaction of Natural Gas (LNG)	Gundersen, Truls	PP
Lindqvist, Karl Erik Arthur	Computational Fluid Dynamics Modeling of Flow and Heat Transfer i Fin-Tube Bundles	Næss, Erling	PP
Meraner, Christoph	On the scalability of a partially premixed low NOx hydrogen burner by numerical simulation	Løvås, Terese	TF
Rohde, Daniel	Dynamic Simulation of Future Integrated Energy Systems	Nord, Natasa	SES
Svarstad, Magni	Fast Transition between Operational Modes of a reversible Pump-Turbine	Nielsen, Torbjørn K	PP
Södersten, Carl-Johan Hugo	Endogenising capital in multi-regional input-output models: implications for sustainability analysis	Wood, Richard	IndEcol
Tengs, Erik Os	Numerical simulation of Fluid Structure Interaction in high head Francis turbines	Storli, Pål Tore	PP
Vilberg, Ingrid	Study of cavitation, pressure pulsations and flow control methods in hydro power plants	Nielsen, Torbjørn K	PP
Volent, Eirik	Particle erosion in control valves	Dahlhaug, Ole G	PP

Find published theses at ntnuopen.ntnu.no

DEPARTMENT ORGANIZATION



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