

2019

ANNUAL REPORT



DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

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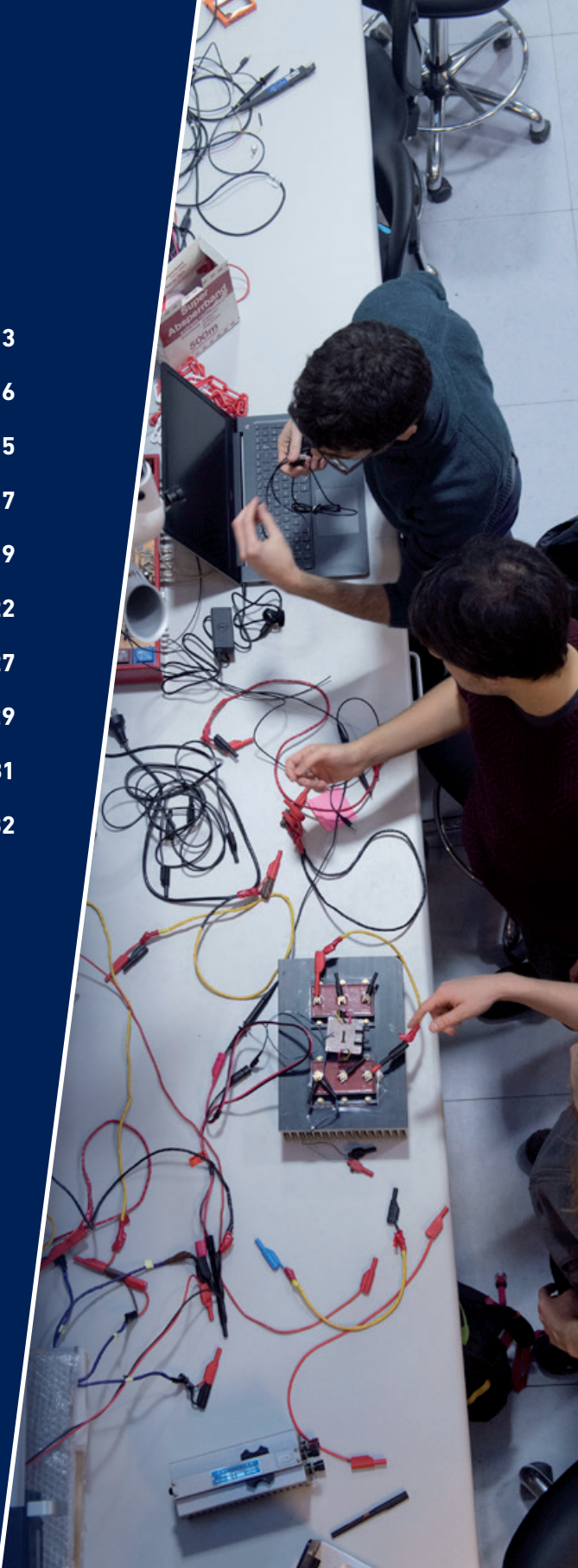
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INTRODUCTION

2019 was another good year for the Department of Energy Technology. In this annual report, you can read about the department's activities and new initiatives that characterised the year.

CHANGE OF MANAGEMENT

In November 2019 the department had a change of management. After 26 years as head, John K. Pedersen went on to take the position as vice dean for research and innovation at the Faculty of Engineering and Science. During this time, the department has undergone a tremendous development to become a national and international leader in energy research and education. We wish John the best of luck in his new position, and look forward to continuing the development with him as a close partner. Until a permanent replacement has been found, Professor Lasse Rosendahl has taken over as acting head of department.

OUTSTANDING RESEARCH

We achieved a broad range of great research results and started many new and exciting projects in collaboration with companies and universities. We are also delighted that two of our professors received international recognition: Professor Frede Blaabjerg received the prestigious world science award 'Global Energy Prize' in acknowledgement of his outstanding contribution to the transition to green energy. And Professor Zhe Chen received international recognition that brings him into the scientific community's Premiere League which happened with the title of IEEE Fellow in the worldwide organization IEEE (Institute of Electrical and Electronics Engineers).

We have been working on approximately 200 different research projects with a turnover of 76 million DKK. Also, in collaboration with the industry and other universities, we have initiated more than 68 new research projects worth 129 million DKK. Please see pages 7-15 and our website et.aau.dk for more information. Another remarkable result is the high number of research publications, around 800, all in high-ranking journals and conferences. Finally, our intake of PhDs remains strong although down from last year. We have graduated 27 and started 21 new PhDs in very exciting projects.

TEACHING AND STUDY ENVIRONMENT

A large number of candidates have finished in all of our specialisations, including several foreign students. We are pleased with an intake of 68 students for the Bachelor's programme in Energy in Aalborg. For the two Bachelor programmes in Esbjerg; Energy and Applied Industrial Electronics the intake was 12 and 13 students respectively. The intake in Esbjerg was a bit lower than expected, so we will make an extra effort in 2020. A new Master's. A new Master's programme, Advanced Power Electronics, will start up in Esbjerg in September. With the goal to strengthen the collaboration between AAU students and industrial partners, a fair was arranged to encourage networking and discussions of joint projects. This event contributes to the mutual understanding between the academic and the industrial world and will be repeated in 2020.

A LOOK INTO THE FUTURE

We will continue to update and develop our research programmes, in order to ensure that they continue to foster high impact research. Read more about the research programmes at et.aau.dk/research-programmes. Another focus point for the coming years is to develop our strong educational programs to make them grow in terms of students and relevance for industry and research institutions. We hope you will enjoy this annual report and look forward to collaborating with you in 2020 where we will be pursuing new goals.



Lasse Rosendahl, Acting Head of Department of Energy Technology

THE DEPARTMENT OF ENERGY TECHNOLOGY

The Department of Energy Technology focuses on a sustainable future, which means that the research focuses on renewable energy, efficient energy consumption and distribution, conversion technologies and control of energy. The department addresses the energy technological challenges, which occur in the pursuit of a society that is free from fossils and based on a robust energy system with a high degree of supply security.

There are a number of challenges within areas such as optimal consumption of biomass and waste, integration of wind, photovoltaic and wave energy in the energy system and configuration of a future intelligent grid including electricity, heat and gas. Furthermore, the department's research investigates challenges with transportation by electric cars, efficient and reliable conversion technologies as well as storage and future houses that produce net energy.

SECTIONS AND RESEARCH PROGRAMMES

To cover the many challenging areas within energy technology, the Department of Energy Technology is organised in seven sections and eighteen research programmes. The seven sections make up the basic organisation of all scientific employees and reflect the primary core competences. Each section has a leader who is part of the department's overall management group. Six sections are placed in Aalborg and one section is placed in Esbjerg.

The eighteen research programmes reflect the current research focuses in technologies and applications. The programmes are dynamic and they continuously adjust to new possibilities. A programme leader is in charge of the programme, its development and its research, PhD and collaboration projects.

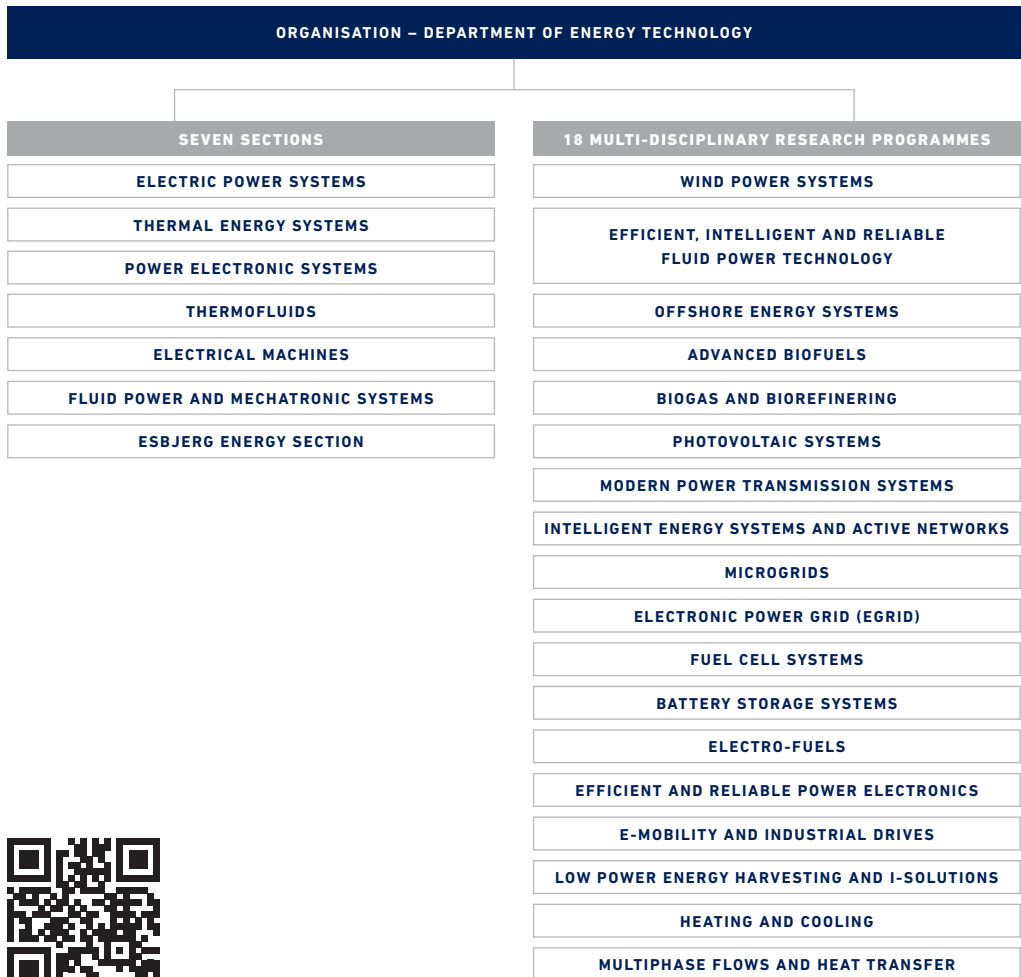
AIMS FOR THE DEPARTMENT OF ENERGY TECHNOLOGY

The department has four overall objectives:

- to conduct definitive international leading edge research with strong industry interaction
- to educate highly qualified candidates at all levels from BSc to MSc and PhD
- to interact with peers in the industry and academia
- to create a good and innovative work environment in the department

CLOSE COLLABORATIONS

The Department of Energy Technology places great emphasis on being international and collaboration oriented with world-class experimental facilities. The department has a comprehensive collaboration with the industry in both research projects and consulting and is proud of the fact that numerous world renowned companies have chosen to have in-house divisions at the department, which contributes to closer collaborations.



KEY FIGURES 2019

THE DEPARTMENT

Publications

2019:.....	820
2018:.....	843
2017:.....	705
2016:.....	610
2015:.....	552
2014:.....	465

Total turnover (m)

2019:.....	138,4
2018:.....	161,7
2017:.....	169,1
2016:.....	163,2
2015:.....	161
2014:.....	130

Graduated PhD students

2019:.....	27
2018:.....	32
2017:.....	30
2016:.....	26
2015:.....	28
2014:.....	19

External turnover (m)

2019:.....	75,6
2018:.....	79,5
2017:.....	88,9
2016:.....	92,0
2015:.....	94,5
2014:.....	72

New PhD students

2019:.....	21
2018:.....	52
2017:.....	45
2016:.....	27
2015:.....	30
2014:.....	31

New external portfolio (m)

2019:.....	129,4
2018:.....	58,7
2017:.....	107,6
2016:.....	77,2
2015:.....	81,5
2014:.....	112,5

Total PhD students

2019:.....	117
2018:.....	129
2017:.....	112
2016:.....	98
2015:.....	99
2014:.....	100

Total number of employees at the department

2019:.....	290
2018:.....	330
2017:.....	280
2016:.....	250
2015:.....	250
2014:.....	230



SELECTED PROJECTS

AQUACOMBINE

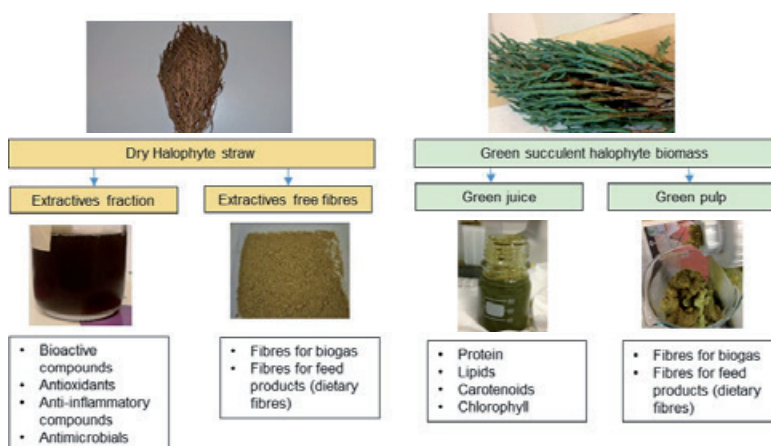
The AQUACOMBINE project aims to demonstrate combined aquaculture and halophyte (saline tolerant plants) farming using the principles of circular economy, where waste is recovered and utilised within the system to create internal value and new products. Excess nutrients from the fish production serve as fertiliser for the halophytes, and is subsequently filtered through a microbial water treatment system to enable recirculation back into the aquaculture tanks. All parts of the halophyte biomass are used for production of multiple products such as food, feed, botanical extracts, and bioactive compounds, as well as biogas from the final residues. This combined aquaculture farming and bioprocessing can help desalinate salt affected areas and can be combined with sustainable management of natural areas and/or use of marginal lands to create value and jobs in rural, remote, and salt affected areas. The bioprocessing will create additional value to the combined farming and diversify products.

Period: October 2019 - September 2023.

Participants: AAU-ET, Luleå University of Technology, Leibniz University Hannover, Hochschule Bremerhaven – University of Applied Sciences, Université Catholique de Louvain, Hochschule Flensburg, University of Aveiro, CIIMAR - Interdisciplinary Centre of Marine and Environmental Research, CELABOR SCRL, Envirohemp S.L., RIASEARCH Unipessoal Lda, Alpha Aqua, Lucas Corinne, Naturfarm Pharmacy, Thise Mejeri, Food Processing Initiative e.V., ADRAL – Alentejo Regional Development Agency.

Funding: H2020. Total project amount: 82,597,510 DKK (department part: 15,616,607 DKK).

Contact person: Associate Professor Mette Hedegaard Thomsen, mht@et.aau.dk.



The halophyte plants are very flexible biorefinery plants, with the potential to co-produce many different bio-products including high-value nutraceutical products.



HOLISTIC AND SCALABLE SOLUTION FOR RESEARCH AND EDUCATION TARGETING ENERGY TRANSITION (ASSET)

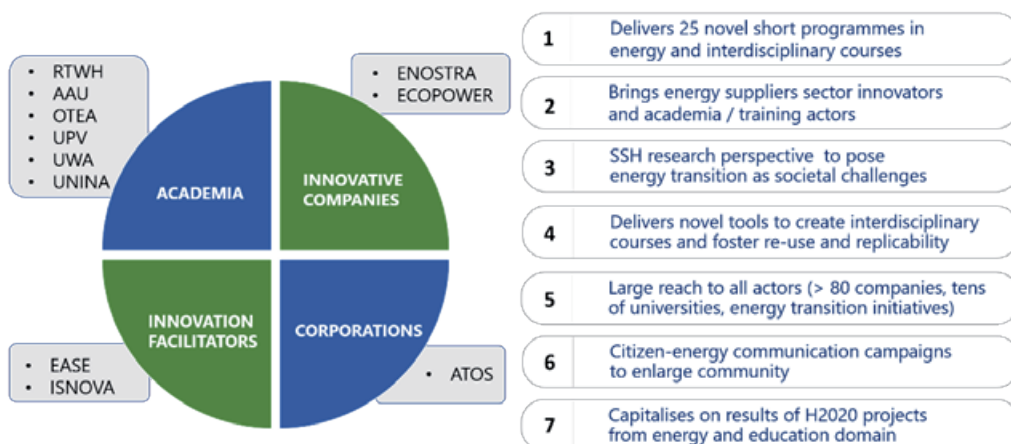
ASSET's goal is twofold: To create a sustainable and scalable ecosystem involving energy transition and education stakeholders (companies from the energy sector, universities and training actors, authorities and policy makers, society). To deliver a framework for the continuous collaborative definition of the knowledge-competencies-skills required for the energy transition to efficiently educate/train large numbers of people via e-learning tools in diverse interdisciplinary topics and carry out research and innovation activities.

Period: May 2019 - March 2021.

Participants: AAU-ET, ATOS, University of Naples Federico II, RWTH, OTE-Academy Greece, University of West Attica, UPV, LogicalSoft, ENOSTRA, ECOPOWER, EASE.

Funding: H2020-LC-SC3-CC5-2018. Total project amount: 14,722,281 DKK (department part: 1,662,290 DKK).

Contact persons: Professor Josep M. Guerrero, joz@et.aau.dk and Professor Juan C. Vasquez, juq@et.aau.dk.



VILLUM CENTER FOR RESEARCH ON MICROGRIDS (CROM)

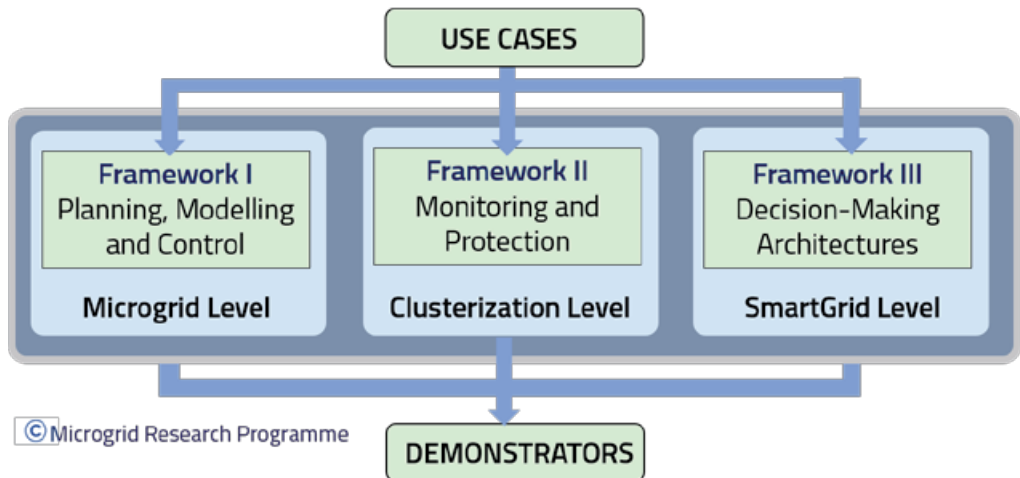
CROM is an international leading research center, located at Aalborg University, Denmark, dedicated to the sustainable development on multi-disciplinary energy frameworks and focused on resilient and energy management solutions applied to land-based, maritime, and aerospace Microgrid architectures. With almost 10 years of experience, CROM currently has more than 50 members involving researchers, PhD students, and visiting scholars. As a major research center, CROM comprises world-class laboratories with large-scale HiL test facilities and establishes R&D&I projects together with industry firms and research institutions worldwide.

Period: August 2019 - July 2025.

Participant: AAU-ET.

Funding: The Velux Foundations. Total project amount: 39,176,745 DKK.

Contact persons: Professor Josep M. Guerrero, joz@et.aau.dk and Professor Juan C. Vasquez, juq@et.aau.dk.



THE VELUX FOUNDATIONS

VILLUM FONDEN ∞ VELUX FONDEN

ELECTRONIC SYSTEMS MANUFACTURED FOR CLIMATE (ELMAC)

The overall objective of the ELMAC project is to develop a climate coupled proactive-design-and-monitoring strategy (PDMS) for industrial partners' electronic products to tune their product to be robust for specific regional climate and secondly building connectivity to the device for predictive maintenance. Outcome significantly cuts the manufacturing, replacement and repair cost incurred due to unknown climate effects. The aim is to develop zonal Climate Transfer Function (CTF) models for coupling with semi-empirical modelling software tool for proactive-device-design, while incorporating climate effect sensing methods to monitor for predictive device health management and maintenance. AAU contribution is twofold 1): To build a semiempirical modelling software design tool to predict condensation-related failure risk and 2) to develop climate-coupled risk prediction models for climate related failure modes of Printed Circuit Board Assembly (PCBAs).

Period: June 2019 – June 2023.

Participants: AAU-ET, Technical University of Denmark, Vestas, FORCE Technology, Danfoss, Grundfos, Eltek, Scanda Minds.

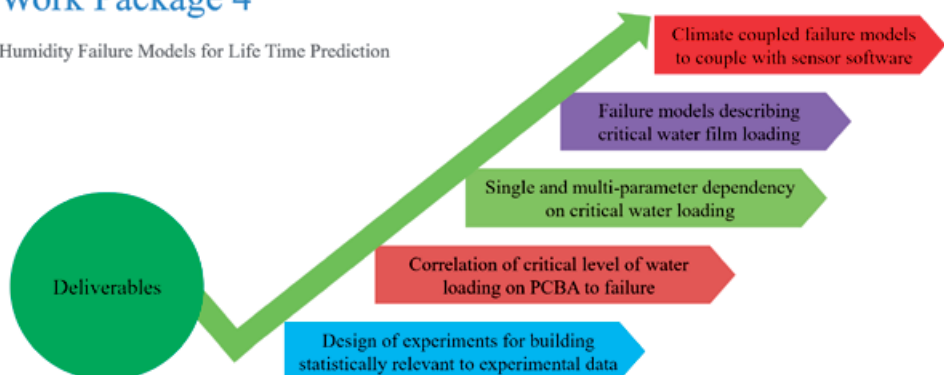
Funding: Innovation Fund Denmark. Total project amount: 32,696,000 DKK (department part: 3,340,800 DKK).

Contact person: Professor Francesco Iannuzzo, fia@et.aau.dk.

Innovation Fund Denmark

Work Package 4

Humidity Failure Models for Life Time Prediction



LIQUID HYDROGEN CONCEPT VALIDATION FOR LARGE EFFICIENT, SCALED AND STACKED FC ELECTRIC POWER SYSTEMS FOR VESSELS (LH2VESSEL)

In the maritime sector international organisations have focused their initiatives on reducing CO₂, SO_x and NO_x emissions – it is therefore paramount to seek solutions to limit pollutions and at the same time to decarbonise boats' gas emissions. Among different options, fuel cells can be used as a zero-emissions solution for the electrification of the power train. If fueled by liquid hydrogen, fuel cells can offer longer operating hours compared to compressed hydrogen or batteries. This project will contribute to a leading role of Denmark in supplying an efficient and zero-emissions energy solution for the maritime sector.

The demonstration of a pilot-size fuel cell system fueled by liquid hydrogen will be the main project outcome. This prototype will be tested in laboratory environment (TRL6). The system is targeted for heavy duty vessels and its design will be approved by DNV-GL.

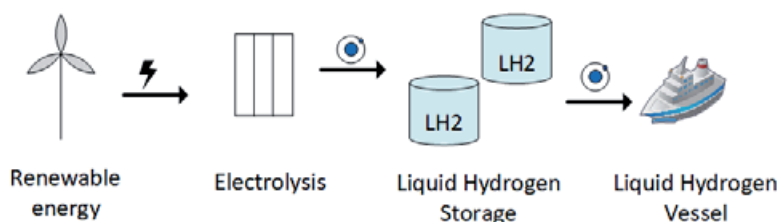
The fuel cell research programme in the department will take a leadership role in designing the energy system. In particular, a scalable modular fuel cell system concept will be developed which will take criteria such as total cost of ownership, energy efficiency and reliability into account. Additionally, due to the use of liquid hydrogen fuel, new solutions will be developed for the hydrogen storage and gas pre-treatment for maritime applications.

Period: November 2019 – December 2022.

Participants: AAU-ET, Ballard Europe, Danish Gas Technology Centre, Odense Maritime Technology, ErhvervsFyn, MAN Cryo.

Funding: EUDP. Total project amount: 18,052,954 DKK (department part: 2,146,753 DKK).

Contact person: Associate Professor Vincenzo Liso, vli@et.aau.dk.



SENSE

High power storage systems represent a solution to problems of power quality in electricity grids and provide grid-friendly quick charging of electrical ferries. The objective of SENSE is to develop, demonstrate and commercialise high power storage systems that outcompete existing solutions. The SENSE frequency regulation system (to be developed and commercialised by the project leader KKWS) and the SENSE Mega Charger (to be developed and commercialised by PowerCon) will be based on novel, safe, cost-effective and sustainable storage cells that combine the benefits of Li-ion batteries and supercapacitors (LiC cells). The LiC cells, developed by the SME partner Beyonder, enable storage systems that surpass competing technologies in terms of power, energy, lifetime, safety, energy efficiency, self-discharge and cost. AAU contributes to the SENSE project by bringing leading expertise in battery research to ensure high performance and lifetime of the LiC cells.

Period: September 2019 – August 2022.

Participants: AAU-ET, KK Wind Solutions, PowerCon, Beyonder.

Funding: EUDP. Total project amount: 29,492,889 DKK (department part: 6,510,737 DKK).

Contact person: Professor Stig Munk-Nielsen, smn@et.aau.dk.



UEBAN WASTE HYDROFACTION

The WaterValue project is a Sino-Danish collaboration aiming to remove economical bottlenecks in sludge disposal in wastewater treatment plants (WWTP), moving beyond current landfilling and incineration and enabling a circular utilisation of sewage sludge. This is done by radically changing the way a WWTP operates, by adopting a hydrothermal process (termed HTL) under development in the Department of Energy Technology, which chemically transforms the organic sludge into a renewable bio-crude and isolating the nutrients. This bio-crude can be further processed into conventional fuels, e.g. jet and marine fuels, and the nutrients, especially phosphorous and nitrogen, can be circulated back to e.g. the agricultural sector. At the same time, the HTL process addresses the concerns about micro-plastics and pharmaceutical residues in wastewater by complete destruction due to high temperature conditions. The WWTP-HTL coupling in the WaterValue project hence enables new business opportunities for turning waste to value not only in a Danish context but also in a global context.

Period: September 2019 - February 2021.

Participants: AAU-ET, Steeper, RenoNord, Aalborg Supply (Sewer), Aalborg Supply (Renovation).

Funding: EUDP. Total project amount: 17,098,959 DKK (department part: 5,948,916 DKK).

Contact persons: Professor Lasse Rosendahl, lar@et.aau.dk and Associate Professor Thomas Helmer Pedersen, thp@et.aau.dk.



WINGRID

The WinGrid consortium aims to train the next generation of researchers on future power system integration issues associated with large-scale deployment of wind generation, focusing on the modelling and control aspects of wind turbine design, and the system stability issues and supervisory structures required for robust implementation. The volume of wind installations is growing rapidly, giving rise to various concerns about future power system stability. More sophisticated modelling capability is required to fully assess the growing complexity as we advance towards a 100% RES resilient power system, while new wind generation technologies are emerging which may radically impact how the future system evolves, against a background of more stringent grid code requirements and emerging system service markets. Highly-skilled researchers, capable of solving such problems, are scarce and in high demand by industry.

WinGrid comprises an expert group of ten academics from eight beneficiary organisations including seven leading universities and one large company DNV GL across six countries. It also has eight internationally renowned industrial partners ranging from wind turbine developer, transmission system operator, power system analysts and renewable energy consultants from six countries. Combined together we provide wide-ranging expertise in power electronics converters, control theory, system stability analysis, power system operation and electricity markets. The Early Stage Researchers will enjoy a highly integrated, multi-disciplinary training environment, including access to specialist software and hardware-in-the-loop test environments, enriched through secondments with the network of industrial partners. WinGrid will enable critical learning across all training aspects, in order to ensure that comprehensive, robust and implementable solutions are obtained and validated to face the grid integration challenges of the future.

Period:	September 2019 – August 2023.
Beneficiary participants:	AAU-ET, University of Warwick, Imperial College London, Christian-Albrechts-Universität zu Kiel, Technical University of Denmark, University College Dublin, Tel Aviv University, DNV GL Netherlands B.V.
Non-Beneficiary participants:	ABB, Vestas Wind Systems, EirGrid Group, Global Energy Interconnection Research Institute Europe GmbH of State Grid Corporation of China, FTI Consulting, Energy Systems Catapult, Rotem Industries Ltd, Dansk Energi.
Funding:	H2020-MSCA. Total project amount: 31,960,627 DKK (department part: 4,276,628 DKK).
Contact persons:	Professor Xiongfei Wang, xwa@et.aau.dk and Professor Frede Blaabjerg, fbl@et.aau.dk.

X-POWER

X-POWER is a cooperation between the major Danish universities to establish a Danish research infrastructure for reliability testing of power electronics components and systems incl. data collection. The research infrastructure is open on equal terms to project partners, academic, and commercial users who would like to exploit the facilities and/or the competences, and users can apply for access to the infrastructure facilities.

The aim of X-POWER is to establish a novel world-class reliability design and test center for power electronic components and systems. X-POWER will support fundamental research in Danish universities on reliability power electronics and facilitate robustness validation of industry products with reduced time-to-market and life-cycle costs. X-POWER will give Danish universities and industry a unique chance to be in the lead in terms of research in power electronics and its applications. In terms of reliability and robustness, the industry will get the latest knowledge in the field and X-POWER will offer test capacity for new developed products, where it is possible both to study in details failure mechanism of developed products, but also be able to test the real mission profile. X-POWER will enable the parties to contribute to and solve many scientific challenges in the area of research in a systematic way.

Period: January 2019 - December 2023.
Participants: AAU-ET, AAU-MP, University of Southern Denmark, Technical University of Denmark.
Funding: Danish Agency for Science and Higher Education. Total project amount: 62,300,000 DKK (department part: 38,250,000 DKK).
Contact person: Professor Frede Blaabjerg, fbl@et.aau.dk.

X-Power – Reliability testing for Enabling Technologies

- Testing of components for renewable power generation
- Application-specific testing for power transmission, distribution, and consumption

X-POWER

 Uddannelses- og
Forskningsministeriet



Generation

Transmission/Distribution

Consumption

AALBORG UNIVERSITY
DEPARTMENT OF ENERGY TECHNOLOGY

GRADUATED PHDS

Rasool Heydari:

High Bandwidth Frequency and Voltage Control in a VSC based AC Microgrid.

Abderezak Lashab:

Topologies and Control in Photovoltaic Systems with and without Storage.

Dapeng Lu:

Stability and Control of Dc-Link Dynamics in Three-Phase Grid-Connected Converters.

Zhongxu Wang:

Mission Profile based Control and Reliability Improvement Strategies of Modular Multi-level Converter.

Mohamed Alhasheem:

Improvement of Transient Power Sharing Performance in Parallel Converter Systems.

Adolfo Garcia Gonzalez:

Recyclable Electrical Machine Designs with 3D Flux and Non-Traditional Materials.

Rakesh Sinha:

Flexible Control for Local Heating and Transportation Units in Low Voltage Distribution System.

Nuri Gökmen:

Analysis of high PV Penetration Impacts and Reactive Power Management in Unbalanced Distribution Grids Including the Secondaries.

Nicklas Christensen:

Demonstration of High Power Density kW Converters Utilizing.

Simon Heindorf Sønderskov:

Predicting Performance Degradation of Fuel Cells in Backup Power Systems.

Karthikeyan Nainar:

Hierarchical Distributed Control of Active Electric Power Distribution Grids.

Basanta Raj Pokhrel:

Improved Observability for State Estimation in Active Distribution Grid Management.

Hechao Wang:

Position Estimation Error Analysis, Self-Commissioning and Compensation for Low-Speed Sensorless Synchronous Machine Drives.

Ionut Vernica:

Model-based Reliability Analysis of Power Electronic Systems.

Pengfei Li:

Frequency Control Strategies of Power System with Renewable Generation Integration.

Lorenzo Ceccarelli:

Advanced Modeling of SiC Power MOSFETs aimed to the Reliability Evaluation of Power Modules.

Nor Baizura Bintiahmad:

Integration of Microgrid Technologies in Future Seaports.

Muzaidi Bin Othman:

Energy Management of Shipboard Power System.

Asger Bjørn Jørgensen:

Packaging of Wide Bandgap Power Semiconductors using Simulation-based Design.

Kasper Lund Jepsen:

Modeling and Control of Membrane Filtration Systems for Offshore Oil & Gas Produced Water Treatments.

Bjørn Rannestad:

Methods of Monitoring and Reliability Improvement of Wind Turbine Converters.

Saeed Sadeghi Lafmejani:

Experimental and Numerical Analysis of Gas - Liquid Flow in PEM Water Electrolysis.

Anders Schou Simonsen:

Modelling and Analysis of Seawater Scrubbers for Reducing SO_x Emissions from Marine Engines.

Sajjad Mahmoudi Nezhad:

Transient Study of Hybrid Concentrating Photovoltaic-Thermoelectric Systems and Solar Thermoelectric Generators.

Roni Irnawan:

Planning and Control of Expandable Multi-Terminal VSC-HVDC Transmission Systems.

Tanaka Takaaki:

Control and Optimization of Modular Multilevel Cascaded Statcom Converters for Offshore Wind Application.

Steffen Frensch:

Lifetime Investigation of PEM Electrolyzers under Realistic Load Profiles.



NEW PHDS

DECEMBER

Chaochao Song:

Efficient and Reliable Dual Active Bridge Converters for Photovoltaic Systems.

NOVEMBER

Amir Basati:

Resilience Analysis of DC Microgrid under Extreme Events.

SEPTEMBER

Amirali Davoodi:

System-Level Reliability Modelling and Evaluation in Power Electronic Based Generation Systems.

Changjiang Zheng:

Insulation Evaluation and Design in Power Electronic Components and Systems.

Gustavo Figueiredo Gontijo:

Medium Voltage AC-AC Modular Multilevel Converter Solution Applied to Pumped Hydro Storage Systems and Wind Turbines.

Kai Yin:

Filling Material Investigation of Composite Cross-arms and Grounding Design of a Composite Transmission Tower for 400 kV Overhead Lines.

Komeil Kohansal Sadetmahaleh:

Hydrothermal Liquefaction of low Value Urban Feedstocks.

Hanchi Zhang:

Transient Lightning Impulse Performance Analysis of a Fully Composite Pylon with an External-grounding Down-lead.

Martin Bendix Fogsgaard:

Multi-Time Scale Modelling of Power Electronic Converters in Power System Applications.

JULY

Mahshid Javidsharifi:

Photovoltaic Energy Supply for Future Energy Neutral Base Stations.

Nick Høy Hansen:

Numerical Study of Black Carbon Particles and their Removal from Ship Exhaust Gas with a Wet Electrostatic Precipitator.

JUNE

Hosein Gholami-Khesht:

Probabilistic Assessment and Robustness Analysis of Power Electronic Sub-System for Grid Applications.

Afshin Loghmani Moghaddam Toussi:

Condition Monitoring & Remaining Useful Life Estimation for Power Electronic Components.

MAY

Xinshuo Wang:

Dynamic Interoperability of Grid-Forming Power Converters in Transmission Grids.

MARCH

Mohammad Yaqoob:

Control, Management and Operation of Nanosatellite Microgrids.

Wenbin Yuan:

Advanced Stability Analysis and Control Framework of Inverter-fed Power System for Stability and Reliability Improvement.

FEBRUARY

Luona Xu:

Control Strategies of Power Electronic Converters for MVDC Shipboard Microgrids.

Meng Chen:

Solid State Synchronous Generator.

JANUARY

José Maurilio Raya Armenta:

Energy Management Systems for Islanded Microgrids with High Penetration of Renewable Energy Resources.

Shan He:

Study of Control for Grid-Connected Inverter based on Multisampling.

Mohammad Ghomi:

Measurement of the Transient Impedance of the Grounding System (Vertical Electrode) Buried in the Multi-Layer Stratified Soil Using Small-Scale Setup.



EDUCATION

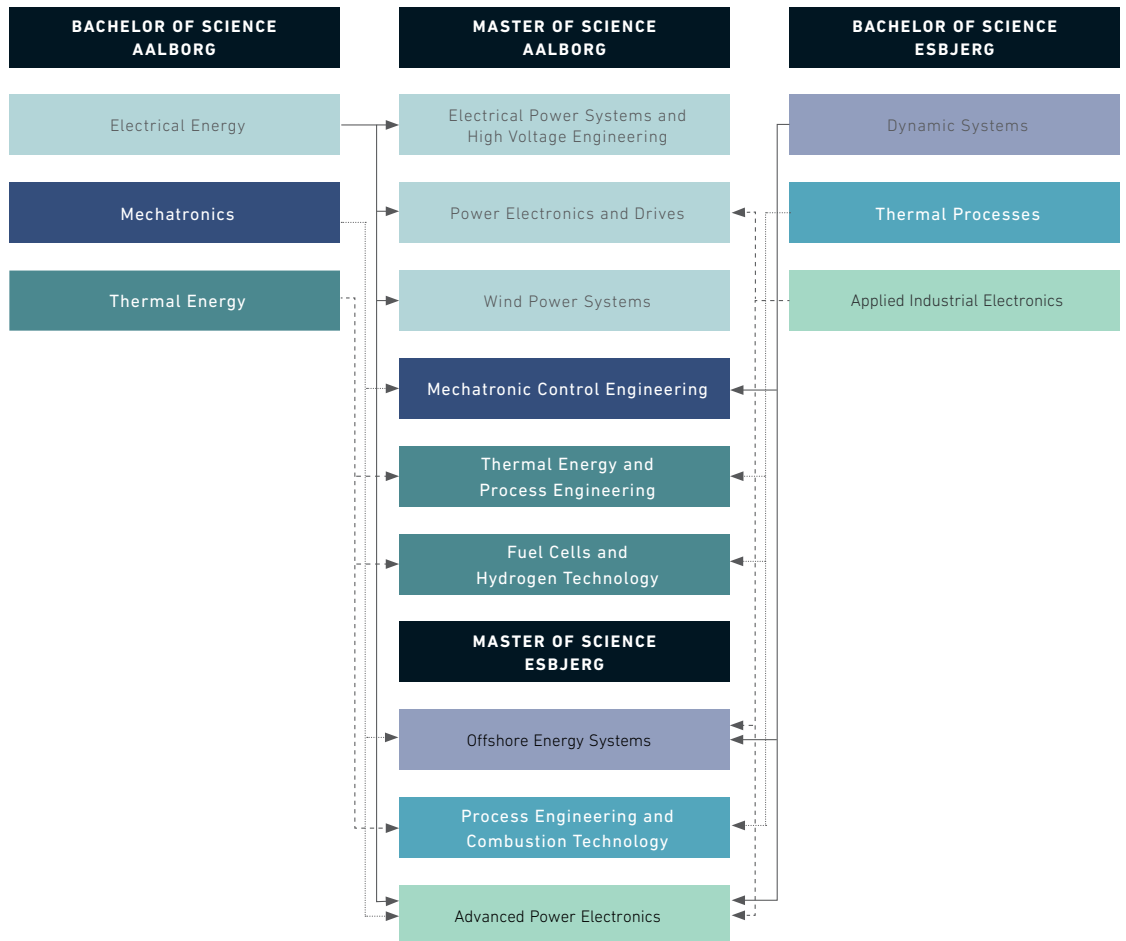
In the Department of Energy Technology we have several up to date energy engineering educations where it is possible to learn about energy production, energy transfer, energy distribution and sustainable energy. The studies are developed in close cooperation with industry and organisations to ensure relevant competences for employment after finalisation of the studies. All studies include relevant energy engineering courses and courses in mathematics and control theory. Depending on specialisation more focus is then put on thermal, electrical or mechatronic aspects. 50% of the time is allocated to project work using problem based learning normally done as team work in groups. All teaching in courses as well as projects is research-based due to the high research level of lecturers and professors in all specialisation areas in the department. This means that the students will always be surrounded by the latest cutting-edge knowledge in their field. Our students will also have many opportunities to test their theoretical knowledge in the department's well-equipped and modern laboratories in both Aalborg and Esbjerg. Furthermore, the department has very good cooperation with industry. Many of the project proposals are offered by the industry and made as a part of their development.

The department offers Bachelor's (undergraduate) and Master's (postgraduate) programmes for international students in both Aalborg and Esbjerg. International students are also welcome to join a study programme as a guest or exchange student.

See the department's study programmes on the next page.



Below you will find the structure of the Energy study programmes and how you can combine a Bachelor's programme and a Master's programme. The options for the Master's programmes depend on the chosen Bachelor's specialisation.



KEY FIGURES 2019

EDUCATION

Student intake (first study year)

Aalborg undergraduate	50
Aalborg bachelor of engineering	18
Esbjerg undergraduate (Energy)	12
Esbjerg undergraduate (Applied Industrial Electronics)	13
Total	93

Student intake Aalborg (Postgraduate)..... 90

Student intake Esbjerg (Postgraduate) 5

Total number of students as of October 1

Aalborg	263
Esbjerg	121
Total	384

Graduated students in Aalborg

Undergraduate.....	50
Bachelor of engineering	2
Postgraduate	48
Total	100

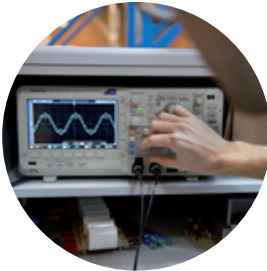
Graduated students in Esbjerg (Energy)

Undergraduate.....	24
Bachelor of engineering	13
Postgraduate	25
Total	62

Graduated students in Esbjerg (Electronics)

Undergraduate.....	30
Bachelor of engineering	0
Postgraduate	2
Total	32

Up to the 6th semester the students may change from bachelor of science to bachelor of engineering and vice versa.



SELECTED NEW LAB FACILITIES

IOT MICROGRID LIVING LABORATORY (IOT-MGLAB)

The IoT-MGLab is a living laboratory that intends to develop and demonstrate cost-effective and comfort-aware solutions for future smart homes and enables the construction of an smart IoT-based infrastructure for its interaction with end-users. IoT-MGLab also serves as a demonstrator to show the viability of low voltage DC and AC systems for future households which will enhance the energy efficiency, flexibility and reliability following Danish smart grid strategy. IoT-MGLab has been established to service several engineering domains (from theory to practice) and to support multi-disciplinary research activities.



MICROGRIDS AND ENERGY INTERNET LABORATORY (MG-EL LAB)

The MG-El Lab is a world class proof-on-concept which facilitates the real-time control, operation, and optimal energy management of renewable energy integration together with energy storage systems, consumption and an Internet of Energy framework. Thanks to its powerful experimental-research-oriented environment, it has been designed to cope the challenges in close collaboration with industrial partners and top-tier universities worldwide. Each workstation provides the flexibility to set multiple hybrid AC and DC Microgrids configurations in grid-connected and islanded modes of operation and Microgrids clusters.



MARITIME MICROGRIDS LABORATORY

The Maritime Microgrids Lab aims at researching energy-efficient, cost-efficient and emission-aware solutions for the next-generation all-electric ship power systems by integrating microgrid technologies in ports and maritime areas. The infrastructure is equipped with power grid simulators, flywheels, bidirectional power electronics converters, electronic loads, multiterminal medium voltage connection and real-time control and monitoring platforms running with different industrial communication protocols.



LOW POWER ENERGY HARVESTING LABORATORY

The Low Power Energy Harvesting Lab facilitates researches and proof-of-concepts for self-powered and independent energy systems by generation of electrical energy from low-thermal, vibration and kinetic energy sources.

Moreover, the laboratory enables advanced studies on temperature management technologies for health treatments and super-cooling of power electronics. The facilities support fabrication of energy harvesting modules such as thermoelectric, piezoelectric and triboelectric, tests and performance measurements, maximum power point tracking, electrical and thermal resistance measurements, 3D printing of devices electrodes, and fatigue, modal and structural analyses through vibration screening by permanent magnet shakers.

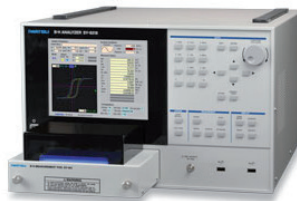


X-POWER

X-Power is a large infrastructure project for reliability testing of power electronic systems. It will encompass testing of new devices, components, equipment, device prototypes, initiating new research projects, and foster cooperation on educational activities. During 2019 the equipment purchase and set up was initiated. Laboratory location has been identified and main auxiliary plants and infrastructure have been planned in detail. Full operation will be in 2020.



PD1500A Dynamic Power Device Analyzer/Double Pulse Tester



Precise automatic core loss measurement in higher frequency



High resolution thermal camera for temperature measurement



High resolution thermal camera for temperature measurement

SMART ENERGY SYSTEMS LABORATORY

PVES (Photovoltaic & Energy Storage) System consists of: i) 3 kWp DC power supply capable of emulating a wide range of PV panels operating in various conditions such as variable solar irradiance and different grades of shading; ii) 6 kWh Li-ion battery and iii) 4 kW grid-connected solar inverter for interfacing the battery and DC power supply with the main grid. Through various dedicated software the system offers different customized options for energy management and system monitoring. New algorithms for energy management and Run-Time dispatching can be developed and tested using the Model Based Design approach.



PVES System Rack Front

PVES System Rack Back



Solar PV Panel Emulator

DRONE AND ROBOTICS LABORATORY

The Drone and Robotics Lab located at Aalborg University Esbjerg Campus, provides facilities for development of various drone technologies and sensing equipment, which can be applied to the drones. The laboratory is equipped with various different drone platforms: from quad/hexa-copters and pipeline crawlers to remotely operated underwater vehicles. Recently the laboratory was equipped with state of the art drone equipment such as the Quanser AVRS system, Consisting of QDrone quadrotors and QBot 2e ground vehicles, ground control station, vision, and safety equipment.



SELECTED EVENTS

ENERGY CONFERENCE IN ESBJERG 2019

April 29th, there was an energy conference at Aalborg University Esbjerg where there, among others, was a presentation by the Minister of Energy, Utilities and Climate Lars Chr. Lilleholt. Politicians, experts and companies participated in the conference where the challenges and possibilities within power supply and industry were on the agenda.

CIGRÉ SYMPOSIUM 2019

June 4th-6th, the department was hosting the 2019 CIGRÉ International Symposium. The theme of the symposium was GOING OFFSHORE – Challenges of the future power grid. The aim of the symposium was to provide a forum for recent research results and system operations experience related to the rapid transformation and challenges imposed on networks and markets by increased amounts of renewables in the energy mix. The symposium was a great success with 336 participants from all over the world.

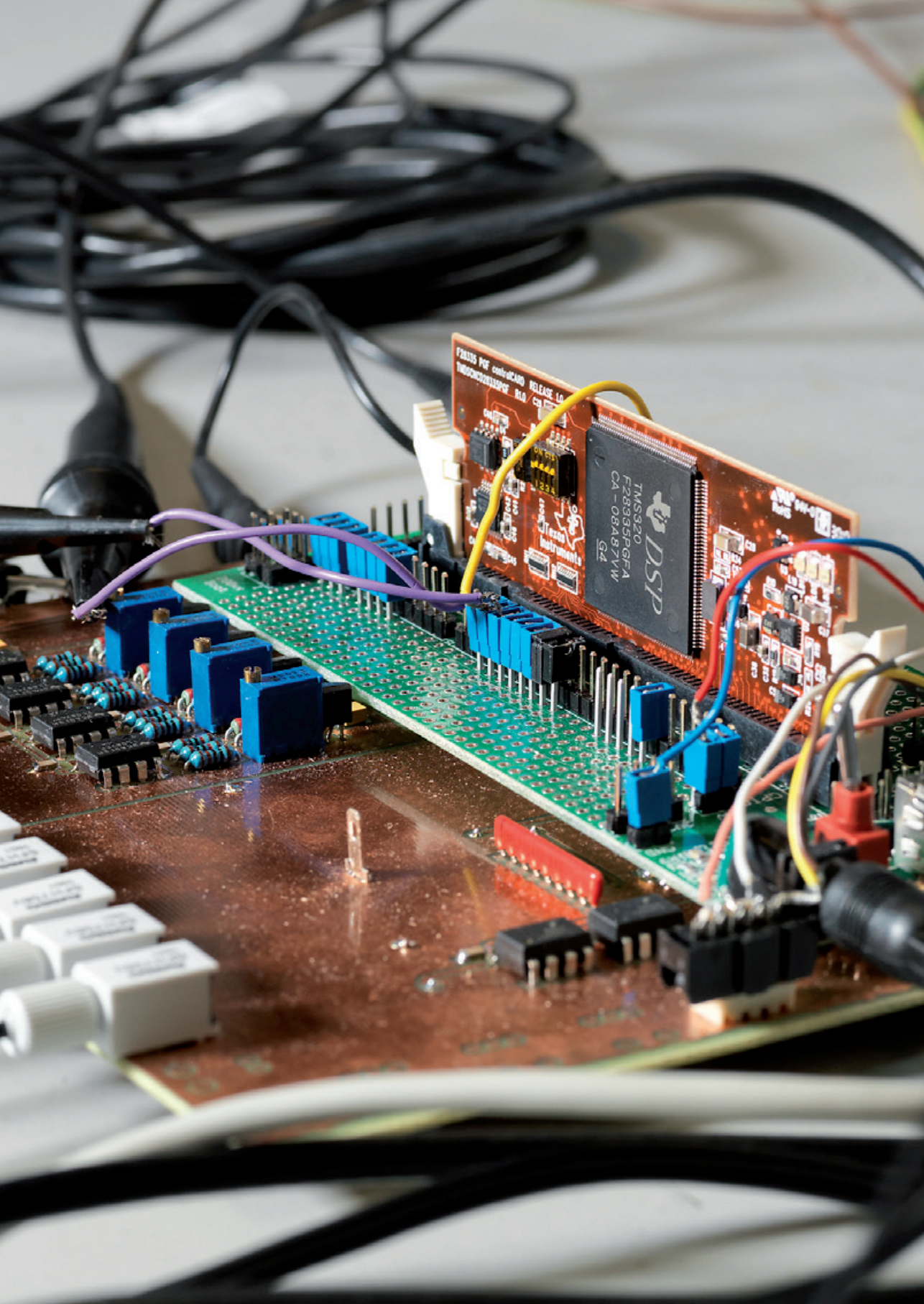


GRADUATION

June 28th, the department held the yearly Graduation Ceremony for candidates graduating from the following six specialisations: 1) Electrical Power Systems and High Voltage Engineering, 2) Mechatronic Control Engineering, 3) Power Electronics and Drives, 4) Thermal Energy and Process Engineering, 5) Fuel Cells and Hydrogen Technology and 6) Wind Power Systems.

After the welcome by Head of Studies, Birgitte Bak-Jensen, guest speaker Thomas Schmidt, Founder and Development Engineer from Schmidt Innovation, held a speech for the graduates. Thereafter, the department's Energy Sponsor Programme represented by Lars Helle from Vestas handed out 1st, 2nd and 3rd prizes to the project groups demonstrating marvellous academic skills, extraordinary engagement and solid work throughout their work with the master thesis. After this, "Teacher of the year" was announced and this year the title was given to Associate Professor Thomas Condra. The ceremony ended with entertainment by the "Energy Band" and the students receiving their diplomas followed by a reception with light refreshments.





AWARDS AND HONOURS



AAU PROFESSOR RECOGNISED WITH THE YOUNG INVESTIGATOR AWARD 2019 BY ELECTRONICS MDPI

Professor Juan C. Vasquez received the Electronics Young Investigator Award 2019. The nomination comprises experienced, highly talented and internationally recognized young researchers with the potential of making a significant breakthrough to research and society. His key research contributions include control, operation, energy management, deployment of sustainable Microgrids with Energy Internet vision.

ARIYA SANGWONGWANICH WINS RESEARCH AWARD

Postdoc Ariya Sangwongwanich received Spar Nord Fondens Forskningspris for his PhD thesis "Grid-Friendly High-Reliability Photovoltaic Systems". In his PhD study, he proposed solutions to ensure smooth integration between the photovoltaic (PV) systems and the electricity network and demonstrated that the PV system can provide much more flexible power injection through the control of power electronic systems. Ariya was awarded 250.000 DKK – of which most will be spent on further research at Aalborg University.



GLOBAL ENERGY PRIZE TO PROFESSOR FREDE BLAABJERG

Professor Frede Blaabjerg has won one of the world's most prestigious research prizes, the Global Energy Prize, for outstanding technical contribution to the design of power management systems enabling the integration of renewable power. The Global Energy Prize is an award for outstanding achievements in the field of energy and the prize was won in the category "non-traditional energy". For 15 years in a row, it was awarded to theorists and practitioners, whose discoveries, developments and technological innovations help all mankind to solve the most acute and challenging energy problems.



PHD FELLOW RODICA ELISABETA STROE WINS BEST PRESENTATION AT ICEMA 2019

The paper "Kinetic study of the photocatalytic degradation of ethylene over TiO₂ thin films" was orally presented by PhD fellow Rodica Elisabeta Stroe at the 4th International Conference on Energy Materials and Applications (ICEMA) held in Beijing, China on 11th -13th May. The paper focused on the derivation of a kinetic model from experimental data describing the photodegradation of ethylene (C₂H₄) over TiO₂ thin films via two different rate laws, while at the same time analyzing the effect of initial C₂H₄ concentration and UV light intensity on the determined kinetics.



RESEARCHERS FROM ENERGY TECHNOLOGY IN ESBJERG RECEIVE BEST PAPER AWARD

Assistant Professor Sanjeevikumar Padmanaban and Associate Professor Jens Bo Holm-Nielsen received the best paper award for the research contribution on the topic: "A New Multilevel Member of Modified CUK Converter Family for Renewable Energy Application". The prize was handed out during the 4th IEEE International Conference on Energy Conversion, IEEE-CENCON, held in Indonesia, on 16th and 17th October.

XIONGFEI WANG RECEIVES IEEE PELS AWARD

Professor Xiongfei Wang received the 2019 IEEE PELS Sustainable Energy Systems Technical Achievement Award as an acknowledgement for his contributions to the "Stability and Control of Power Converters for Renewable Energy Systems". The Sustainable Energy Systems (SES) Technical Achievement Award of the IEEE Power Electronics Society (PELS) has been established to recognize and honor individuals who have contributed with sustained and significantly scholar and original technical and scientific contributions towards the advancement of power electronics in the area of sustainable energy systems.



PHD STUDENT MATEJA NOVAK RECEIVES THE OUTSTANDING YOUNG EPE MEMBER AWARD

In September Mateja Novak received the Outstanding Young EPE Member Award for the paper presented at EPE'18 on "Applying the Statistical Model Checking Approach for the Performance Validation of the FS-MPC Controlled NPC Converter". The co-authors of the paper are Associate Professor Tomislav Dragičević and Professor Frede Blaabjerg.



"BEST ORIGINALITY AWARD" AT TECO GREEN TECH 2019 IN TAIWAN

The two Postdocs Haoran Wang and Ionut Vernica and Professor Huai Wang from Efficient and Reliable Power Electronics Research Programme and Assistant Professor Qian Wang from Modern Power Transmission Systems Research Programme received the "Best Originality Award" in the Final Competition of TECO Green Tech International Contest that took place in Taipei on 21st August. The four scientists are all part of the group "Smart Capacitor" from the department.



PHD STUDENT ELIANA LOZANO WINS BEST POSTER AWARD AT THE EUBC&E 2019

PhD student Eliana Lozano won Best Poster Award at the EUBC&E 2019 conference in Lisbon. The poster was entitled: "Modelling of the integration of HTL with CCS for the production of drop-in biofuels".



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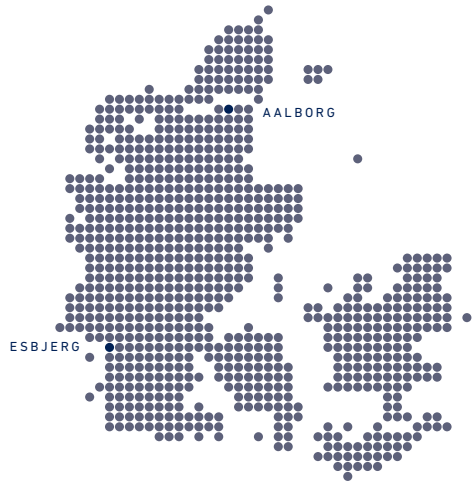
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