



**DEPARTMENT OF ENERGY TECHNOLOGY**  
AALBORG UNIVERSITY



# Annual Report 2013



LECTURE AT THE  
DEPARTMENT

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INAUGURATION HTL  
BIO-OIL RESEARCH  
FACILITY



## Introduction

In spite of overall economic challenges at Aalborg University, 2013 was a successful year for the Department of Energy Technology. We succeeded in realising an ongoing growth contemporary with the achievement of a very positive economic result. We achieved a broad range of great research results and started many new and exciting research projects in collaboration with companies and universities. Furthermore, a high number of PhDs started and we welcomed many new students and graduated a range of new candidates for the industry. In 2013 we also continued the sweeping renovation of our laboratory facilities in both Aalborg and Esbjerg. In both 2014 and 2015 we are looking forward to inaugurating a number of new laboratories which will be of benefit to students as well as researchers and the external cooperation.

In terms of education we are very pleased with our student intake in 2013; in Aalborg with 64 students and in Esbjerg with 36 students within energy and 25 within electronics on first year. Likewise, a large number of candidates have finished in all of our specialisations, including several foreign students.

In terms of research we have once again achieved excellent results and increased all of our key figures. This includes among others 28 new PhD projects, more than 35 new external research projects and an external turnover of 66 million DKK. Moreover, we have in 2013 achieved a record of 424 research publications and increased our focus on the best publication channels. In collaboration with industry and other universities we have initiated a range of projects, which all have started out well to the satisfaction of all parties. Furthermore, we have continued the positive progress of a number of large ongoing research projects such as CORPE, IEPE etc.

In this annual report you can read more about the results from the Department of Energy Technology in 2013. We have selected some of our best and most important results and activities within a selection of the areas we work in. However, not all our work is presented in this report and therefore, we refer you to our homepage for further information: [www.et.aau.dk](http://www.et.aau.dk).

We are very pleased with our results in 2013 and are ready to pursue new goals in 2014 - in collaboration with all of you.

A handwritten signature in blue ink, appearing to read 'John K. Pedersen'. The signature is fluid and cursive.

John K. Pedersen  
Head of Energy Department

# The Department

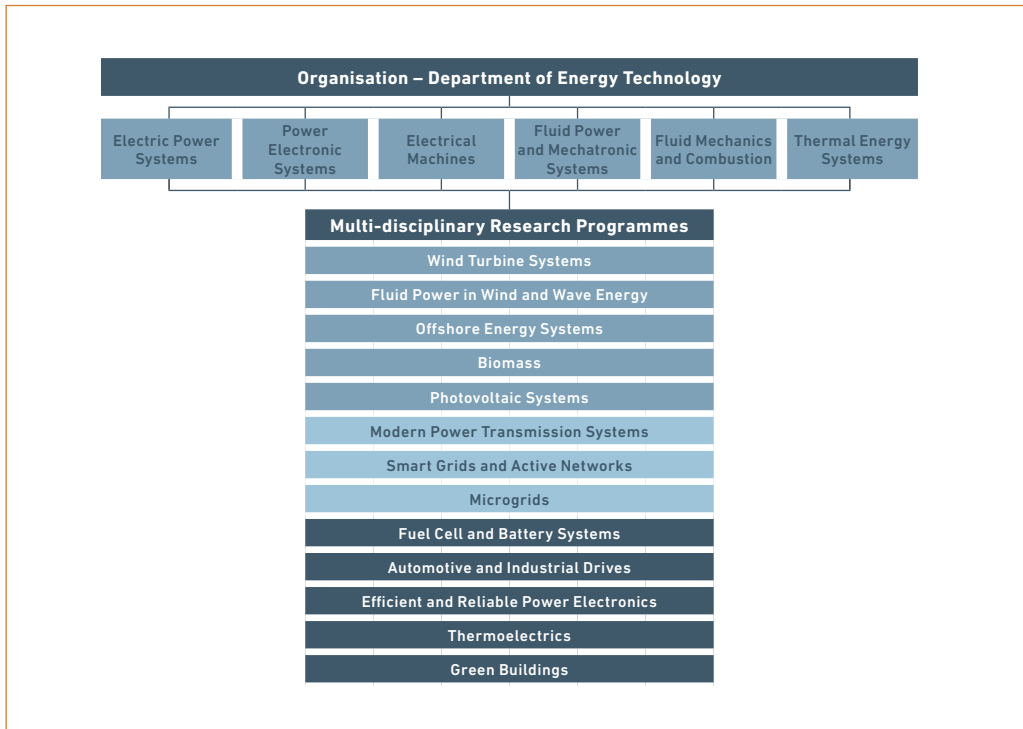
The Department of Energy Technology focuses on a sustainable future, thus research is carried out in renewable energy, efficient energy consumption and distribution, conversion technologies and control of energy. The department addresses the energy technological challenges, which are met on the path to a society free from fossils, based on a robust energy system with a high degree of supply security.

This is connected to a number of challenges within e.g. optimal consumption of biomass, integration of wind-, photovoltaic- and wave energy in the energy system and configuration of a future intelligent grid. Furthermore, research is carried out with regards to challenges with transportation by electric cars, efficient and reliable conversion technologies and future houses, which produce net energy.

## Sections and research programmes

To meet these challenges, the Department of Energy Technology is organised in six sections and thirteen research programmes. The six sections make up the basic organisation of all scientific employees and reflect the primary core competences.

The research programmes reflect the current research focus in technologies and applications. The programmes are dynamic and continuously adjusted to new possibilities. Each research programme contains a series of research-, PhD- and collaborations projects and has a programme leader, who is in charge of the programme and its development.



### Aims for the Department of Energy Technology

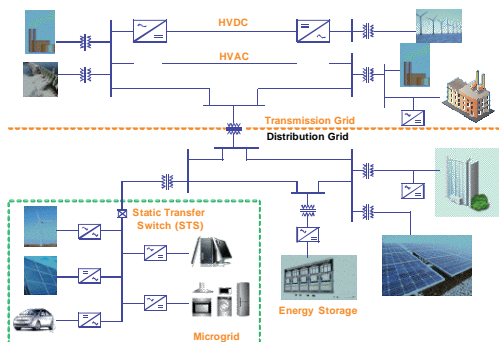
The department has three overall aims:

- to conduct definitive international leading edge research with strong industry interaction.
- to educate highly qualified candidates at all levels from Undergraduate to Post-graduate and PhD.
- to interact with peers in the industry and academia.

### Close collaborations

The Department of Energy Technology places great emphasis on being an international and collaboration oriented university 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 ever closer collaborations.

# Selected Projects



## HARMONY - Harmonic Identification, Mitigation and Control in Power Electronics Based Power Systems

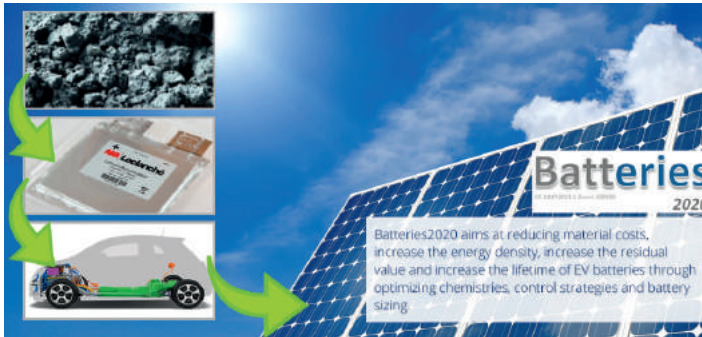
Today the electric power production is changing from conventional, fossil based sources to renewable energy resources. Highly efficient and sustainable power electronics are increasingly used in power generation, power transmission/distribution and end-user applications. Such large scale expansion of power electronics usage will change the characteristic of the power system by introducing more harmonics and resulting in a larger risk of instability and more losses in the future power system. The goal of this project is to obtain "Harmony" between the renewable energy sources, the future power system and the loads in order to keep stability at all levels seen from a harmonic point of view. The project establishes the necessary theories, models and methods to identify harmonic problems in a power electronic based power system, a theoretical and hardware platform to enable control of harmonics and mitigate them, and develops on-line methods to monitor the harmonic state of the power system. Further, new design methods for active and passive filters in renewable energy systems, in the power system and in the power electronics based loads will be developed.

*Period:* February 1 2013 - January 31 2018.

*Participant:* Aalborg University.

*Funding:* European Research Council – Advanced Grants. Total project amount: 18,625,000 DKK.

*Contact Person:* Professor Frede Blaabjerg – [fbl@et.aau.dk](mailto:fbl@et.aau.dk).



## Batteries 2020: Towards Realistic European Competitive Automotive Batteries

The project aims to improve performance, lifetime and total cost of ownership of batteries for EVs by the simultaneous development of high-performing and durable cells, reliable lifetime prediction, understanding ageing phenomena and assessment of second life in renewable energy applications. The most important objective is the battery cost reduction via:

- better understanding of ageing
- better materials resistant to ageing
- higher residual value through second life application understanding.

*Period:* September 1 2013 - August 31 2016.

*Participants:* IK4 – IKERLAN, VuB, Umicore, Leclanche, CR Fiat, Abengoa, Eurobat, ISEA RWTH Aachen and Aalborg University.

*Funding:* Seventh Framework Programme (FP7). Total project amount: 62,786,326 DKK (Dept. of ET part 3,393,271 DKK).

*Contact Person:* Professor Remus Teodorescu – ret@et.aau.dk.

**Batteries**  
2020

## Selected Projects

*Bioenergy seminar;  
04-08.11.2013,  
36 participants from  
6 universities in  
Northern Europe  
and 20 nationalities*



## Energy Campus Esbjerg

The goals of the project is to develop intensified cooperation and draw attention between Energy Companies, highly skilled and trained young potential staff members and higher education institutions in the region of Southern Denmark. The focus area is especially the expanding Energy Cluster in the area of Esbjerg.

The Energy Campus Esbjerg project has three working areas. The first one focuses on innovation developments among Energy SMV's. The offspring is to attack innovation ideas directly in the small companies and demonstrate the values of participation in project based learning camps and maturing ideas of their own processes and needs.

The second task is to attract highly educated young engineers and academics by making summer school types of seminars and training programmes for European youth in the final stages of Master and/or PhD educations. It consists of front edge presentations, study visits at companies, site visits, job contact and a mini job fair. These seminars' are in the working fields of Offshore Wind installations, Oil & Gas technology, Bio energy and Bio refineries and in Smart Grid contexts.

The final task is to develop camp ideas for young students at the level of high schools to make it even more attractive to study engineering with the focus on Energy and Electronic Engineering. The camp and workshop ideas are further enhancing the gained knowledge during the project "Energy on the Ocean" finalized spring 2013.

*Period:* June 5 2013 - December 31 2014.

*Participants:* Aalborg University – ET lead partner, ET-Esbjerg campus & University of Southern Denmark, IME – Esbjerg campus and EASV – Business academy of Southern Jutland and Energy Cluster Companies in the Esbjerg area.

*Funding:* Total project amount: 4,641,918 DKK (Dept. of ET part: 1,737,035 DKK).

*Contact Person:* Associate Professor Jens Bo Holm-Nielsen, Esbjerg Campus - [jhn@et.aau.dk](mailto:jhn@et.aau.dk).





### Advanced Components for Electro-Mobility Usage (ACEMU)

The ACEMU project aims to develop better and more competitive components within the area of E-Mobility. Specifically, a battery driven compactor for garbage trucks is targeted in this project in order to reduce the acoustic noise, CO<sub>2</sub> and particle emissions and total fuel consumption. Another important aspect of the research is the use of a new emerging battery technology, Lithium Sulfur (Li-S), which has a very high energy density, is robust against faults and has a low hazard level.

*Period:* January 1 2014 - December 31 2017.

*Participants:* Aalborg University, Banke Accessory Drives, Lithium Balance and Meldgaard Miljø.

*Funding:* DSF and EUDP. Total project amount: 14,458,337 DKK (Dept. of ET part: 8,097,896 DKK).

*Contact persons:* Professor Remus Teodorescu - ret@et.aau.dk and Associate Professor Erik Schaltz - esc@et.aau.dk.

### Single Blade Installation in high Wind Speeds

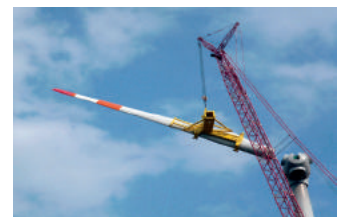
When installing wind turbines, interruption and delay of the installation process due to high wind speeds are a huge cost for the wind industry, especially offshore. This is in contradiction to the turbines being installed in locations with high wind speeds to generate the most power output. The objective of this project is therefore to raise the limit for single blade installation in high wind speeds, by actively controlling the Blade Dragon lifting equipment to counteract wind disturbances.

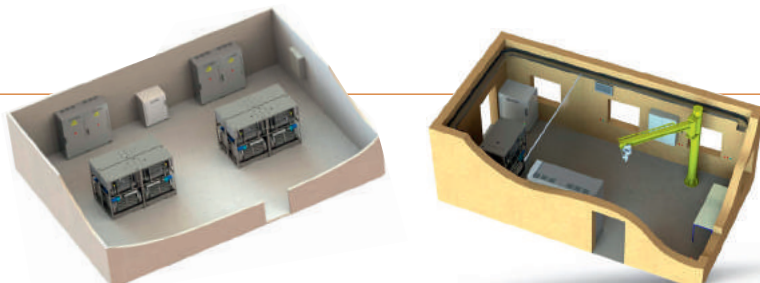
*Project period:* July 1 2013 - May 31 2016.

*Participants:* Aalborg University, Liftra ApS and DTU Wind Energy.

*Funding:* EUDP. Total project amount: 13,091,620 DKK (Dept. of ET part: 1,560,169 DKK).

*Contact Person:* Associate Professor Henrik C. Pedersen – hcp@et.aau.dk.





### Power-2-Electrolysers

In order to reach 100% renewable energy by 2050 it is imperative to focus on energy conversion and storage. In such scenario electrolysis can become a keystone in the energy system. The objectives are to reduce the overall cost and increase the efficiency of the electrolyser power supply. Moreover it will include development and optimization of business models for the operation of large electrolysis systems with focus on intelligent purchase of electricity and sale of ancillary services to the grid.

*Period:* October 1 2013 - July 31 2016.

*Participants:* GreenHydrogen.dk ApS, Haldor Topsøe A/S, LeanEco A/S, Aalborg University and Aarhus University.

*Funding:* EUDP. Total project amount: 13,211,280 DKK (Dept. of ET part: 4,701,227 DKK).

*Contact Person:* Professor Frede Blaabjerg – fbl@et.aau.dk.

### Reliability of Capacitors in Power Electronic Systems (ReliaCap)

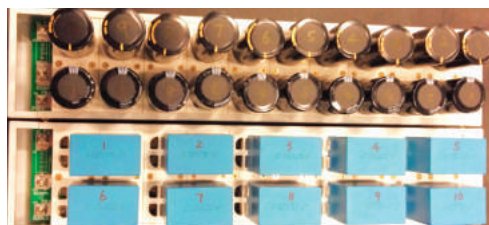
The ReliaCap project addresses the better understanding of reliability of capacitors under various electrical, thermal and environmental stresses. It makes efforts to design more reliable DC-links and to develop associated design tools for power electronic converters and systems in renewable sources and energy efficient applications.

*Period:* January 1 2013 - December 31 2014.

*Participant:* Aalborg University.

*Funding:* The Danish Council for Independent Research - Technology and Production Sciences - (FTP) Individual Postdoctoral Grant. Total project amount: 2,245,735 DKK.

*Contact Person:* Assistant Professor Huai Wang – hwa@et.aau.dk.





## Alpes

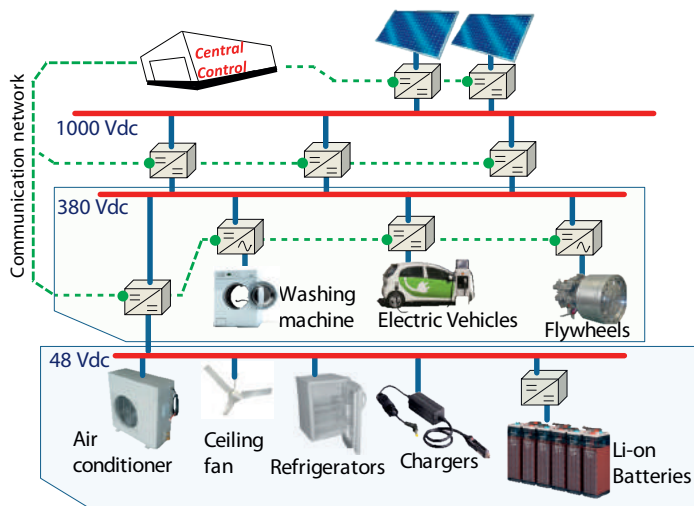
Advances in battery technology have opened possibilities for application of high power and high energy lithium-ion batteries but the economic feasibility depends strongly on lifetime and degradation rates. The ALPBES project takes a leap from developed battery cell degradation modelling and characterisation into full scale battery system degradation modelling and characterisation. The results will be demonstrated to UPS, motion power, and grid balancing in collaboration with industry partners.

*Period:* February 1 2013 - January 31 2017.

*Participants:* Aalborg University, DTU Energy Conversion and Storage, Danish Technological Institute, Lithium-Balance, GMR Maskiner, LeanEco, Royal Institute of Technology (Sweden) and Aachen University (Germany).

*Funding:* Total project amount: 25,300,000 DKK (Dept. of ET part: 11,200,000 DKK).

*Contact Person:* Professor Søren Knudsen Kær – [skk@et.aau.dk](mailto:skk@et.aau.dk).



Living DC Microgrid Lab

### Future Residential LVDC Power Distribution Architectures

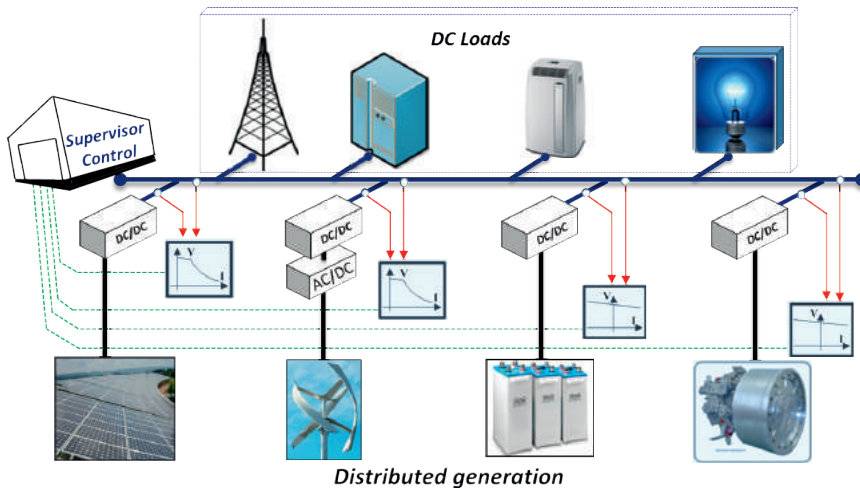
Recently, direct current (DC) distribution systems started to attract a lot of attention as they offer a natural interface to generation and consumption units such as renewable sources, energy storage systems and end-user electronic loads. However, a number of technical challenges related to lack of standardized equipment, stability and control must be overcome. The outcome of this project will be a research-oriented framework for assessment of stability and reliability of LVDC distribution systems.

*Period:* January 1 2014 - December 31 2015.

*Participants:* Aalborg University, Kamstrup A/S, KK-Electronic A/S, Neogrid Technologies, INESC Porto- Engineering of Porto University (Portugal), Ritsumeikan University (Japan) and Center of Power Electronics Systems (United States).

*Funding:* Danish Council for Independent Research - Technology and Production Sciences DFF – Individual Postdoctoral Grant. Total project amount: 2,115,152 DKK (Dept. of ET part: 2,115,152 DKK).

*Contact Person:* Postdoc Juan C. Vasquez – juq@et.aau.dk.



*Power stage and control DC microgrid architecture*

### Intelligent DC Microgrid Living Lab – iDCLab

The research project focuses on the development of future intelligent direct-current (DC) microgrids which is deployed for highly efficient integration of distributed generation and modern electronic loads. The project aims to explore the different aspects of DC microgrids: design, modeling, control, coordination, communications and management. Research will be carried out in DC microgrid living labs focused on commercial buildings and residential applications.

*Period:* January 1 2014 - December 31 2017.

*Participants:* Aalborg University, North China Electric Power University, Smart Grid Research Institute of the State Grid Corporation of China, Power Research Institute (China) and Chinese Academy of Sciences.

*Funding:* DSF. Total project amount: 5,396,587 DKK.

*Contact Person:* Professor Josep M. Guerrero - joz@et.aau.dk.

# SMARTC<sup>2</sup>NET



## Smart Control of Energy Distribution Grids over Heterogeneous Communication Networks

The SmartC2Net project is developing, implementing and validating robust solutions that enable Smart Grid operation on top of heterogeneous off-the-shelf communication infrastructures with varying properties. The main objectives of the project are to: provide a reliable energy infrastructure at low infrastructure costs; position the capabilities of telecommunication operators and energy system integrators in the Smart Grid value chain creating benefits for all stake-holders; strengthen European research and industrial innovation in the area of Smart Grids via the combination of different research fields.

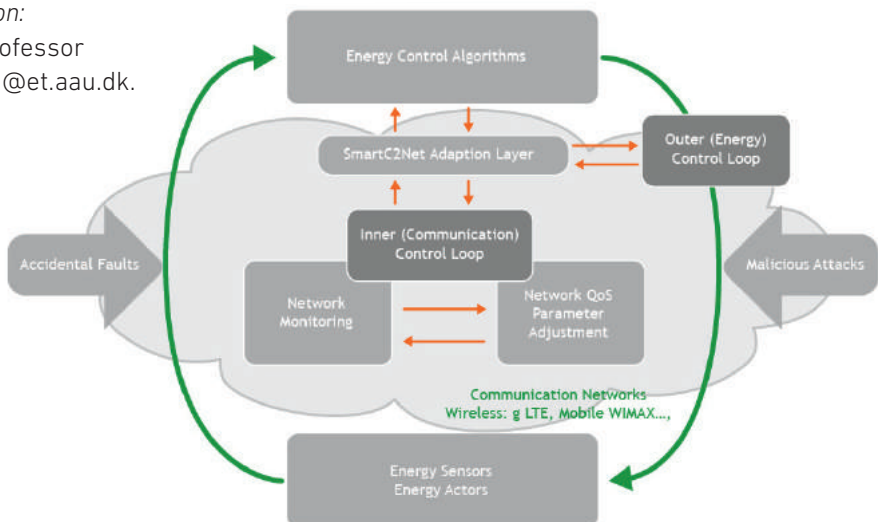
*Period:* December 1 2012 - November 30 2015.

*Participants:* Aalborg University (Dept. of Energy Technology and Dept. of Electronic Systems), FTW Forschungszentrum Telekommunikation Wien GmbH (Austria) – Project leader, Technische Universität Dortmund (Germany), Resiltech Srl (Italy), RicercaSul Sistema Energetico - RSE Spa (Italy), Vodafone Omnitel N.V. (Italy) and EFACEC Engenharia e Sistemas SA (Portugal).

*Funding:* EU FP7. Total project amount: 36,505,000 DKK (Dept. of ET part: 1,868,420 DKK).

*Contact Person:*

Associate Professor  
Florin Iov – [fi@et.aau.dk](mailto:fi@et.aau.dk).



## **DECEMBER:**

### **JunBum Kwon:**

Harmonic System Analysis of Generator and Loads.

### **Bo Sun:**

Control Strategies for Hybridized Energy Storage Systems in MicroGrid Applications.

### **Chi Zhang:**

DC Distribution Power System.

### **Hengwei Lin:**

Monitoring, Management and Protection for Microgrids.

## **NOVEMBER:**

### **Baohua Zhang:**

Wind Power Plant Control.

### **Changwoo Yoon:**

Small Scale Harmonic Power System Stability.

### **Xiaoxu Zhang:**

A Novel Magnetic Gear Integrated Wind Power Generator and Control System.

## **OCTOBER:**

### **Emanuel-Petre Eni:**

Medium Voltage Multi-Megawatt Converter based on SiC Devices.

### **Petar Durdevic Løhndorf:**

Plant-Wide Separator Level and Hydro-cyclone Control.

## **SEPTEMBER:**

### **Yajuan Guan:**

Ancillary Services for Microgrids.

### **Mohammad Rezwana Khan:**

Thermal Management of Battery Packs.

## **AUGUST:**

### **Casper Vadstrup:**

Inverter Output Filters for Wide Band Gap Device Based Adjustable Speed Drives.

### **Simon Pedersen:**

Plant-Wide Anti-Slug Control.

## **JULY:**

### **Carolina Carmo:**

Modelling and Development of Innovative Dual-Mode Smart-Grid Heat Pump with HP2Grid Functionality.

### **Lorand Bede:**

Advanced and Robust Control of Grid Connected Converters.

**Remus Narcis Beres:**

Optimized Design of Power Filters.

**Nan Qin:**

Voltage Control in the Future Power Transmission Systems.

**JUNE:**

**Jorge Varela Barreras:**

Battery Management Systems for Li-Ion batteries.

**Ana-Irina Stan:**

Accelerated Lifetime Test Methods for Li-Ion Batteries.

**MAY:**

**Ghanshyamsinh Vijaysinh Gohil:**

Modular Power Converters.

**APRIL:**

**Muhammad Imran Raja:**

Efficient Adaptive Controller based on Model Predictive Control for Wind Turbines.

**Hamid Soltani:**

Interharmonics Analysis and Mitigation in Adjustable Speed Drives.

**Uimin Choi:**

Modeling of Real-World Stress in Power Semiconductor Devices.

**Nelson Leonardo Diaz Aldana:**

Coordinated Control and Management of Distributed Energy Storage Systems for Microgrids.

**MARCH:**

**Elena Anamaria Man:**

Power Electronics for Oxide-based high Temperature Thermoelectric Generators.

**JANUARY:**

**Nick Baker:**

Electro-thermal Modelling of Power Semiconductor Devices.

**Hui Liu:**

Reliability Analysis of HVDC for Off-shore Wind Power Plant.

**Tonny Christiansen:**

Long Term Stability and Failure Mechanism in Capacitors.



**Jessica Hoffmann:**

Bio-oil Production - Process Optimization and Product Quality.

**Rico Hjerem Hansen:**

Design and Control of the Power Take-Off System for a Wave Energy Converter with Multiple Absorbers.

**Zhou Liu:**

Multi Agent System Based Wide Area Protection Strategy against Cascading Events.

**Cristian Busca:**

Lifetime Prediction of High-Power Press-Pack IGBTs in Wind Power Applications.

**Chengxi Liu:**

Intelligent Control and Protection Methods for Modern Power System Based on Wide Area Measurement System.

**Zhen Sun:**

Nonlinear System Identification and its Application to Fault Detection and Diagnosis.

**Christian Flytkjær Jensen:**

Online Fault Location on AC Cables in Underground Transmission Systems.

**Ke Ma:**

Power Electronics for the Next Generation Wind Turbine System.

**Souman Rudra:**

Design and System Analysis of Quad-Generation Plant Based on Biomass Gasification Integrated with District Heating.

**Søren Stubkier:**

Hydraulic Soft Yaw System for Multi MW Wind Turbine.

**Yunqian Zhang:**

Load and Flicker Mitigation of Grid-Connected Wind Turbines with DFIG.

**Anders Christian Olesen:**

Macroscopic Modeling of Transport Phenomena in Direct Methanol Fuel Cells.

**Yan Liu:**

The Study on Hybrid Multi-Infeed HVDC System Connecting with Offshore Wind Farm.

**Maryam Momeni Kouchaksaraeia:**

Fundamental Study of Single Biomass Particle Combustion.

**Xiongfei Wang:**

Harmonic Mitigation in Islanded Micro-grids by Inverter-Interfaced Distributed Energy Resources.

## Selected Journal Papers

Statistical Distribution of Energization Overvoltages of EHV Cables  
Teruo Ohno, Claus Leth Bak, Akihiro Ametani, Wojciech Wiechowski, Thomas K. Sørensen  
I E E E Transactions on Power Delivery, Vol. 28, No. 3, pp. 1423-1432.

Analysis of the Passive Damping Losses in LCL-Filter-Based Grid Converters  
Rafael Pena Alzola, Marco Liserre, Frede Blaabjerg, Rafael Sebastián, Jörg Dannehl,  
Friedrich Wilhelm Fuchs  
I E E E Transactions on Power Electronics, Vol. 28, No. 6, pp. 2642-2646.

Control and Experimental Characterization of a Methanol Reformer for a 350 W High Temperature Polymer Electrolyte Membrane Fuel Cell System  
Søren Juhl Andreasen, Søren Knudsen Kær, Simon Lennart Sahlin  
International Journal of Hydrogen Energy, Vol. 38, No. 3, pp. 1676-1684.

Grid Simulator for Power Quality Assessment of Micro-Grids  
Joaquin Eloy Garcia Carrasco, Juan Carlos Vasquez, Josep M. Guerrero  
I E T Power Electronics, Vol. 6, No. 4, pp. 700-709.

Individual Module Maximum Power Point Tracking for Thermoelectric Generator Systems  
Casper Vadstrup, Erik Schaltz, Min Chen  
Journal of Electronic Materials, Vol. 42, No. 7, pp. 2203-2208.

Optimization of a High Temperature PEMFC micro-CHP System by Formulation and Application of a Process Integration Methodology  
Alexandros Arsalis, Mads Pagh Nielsen, Søren Knudsen Kær  
Fuel Cells, Vol. 13, No. 2, pp. 238-248.

Simple Neutral-Point Voltage Control for Three-Level Inverters Using a Discontinuous Pulse Width Modulation

Uimin Choi, Kyo Beum Lee, Hyun-Hee Lee

*I E E E Transactions on Energy Conversion*, Vol. 28, No. 2, pp. 434-443.

Oxy-Coal Combustion in an Entrained Flow Reactor: Application of Specific Char and Volatile Combustion and Radiation Models for Oxy-Firing Conditions

Lucia Álvarez, Chungun Yin, Juan Riaza, Covadonga Pevida, José Juan Pis, Fernando Rubiera  
*Energy*, Vol. 62, pp. 255-268.

An Optimization Method for Designing Large PV Plants

Tamas Kerekes, Eftichis Koutroulis, Dezso Sera, Remus Teodorescu, Markos Katsanevakis

*I E E E Journal of Photovoltaics*, Vol. 3, No. 2, pp. 814-822.

Control of Improved Full-Bridge Three-Level DC/DC Converter for Wind Turbines in a DC Grid

Fujin Deng, Zhe Chen

*I E E E Transactions on Power Electronics*, Vol. 28, No. 1, pp. 314-324.

Radius Ratio Effects on Natural Heat Transfer in Concentric Annulus

Mahdi Alipour, Reza Hosseini, Alireza Rezania Kolaei

*Experimental Thermal and Fluid Science*, Vol. 49, pp. 135-140.

SuperGrid or SmartGrid: Competing Strategies for Large-Scale Integration of Intermittent Renewables?

Morten Blarke, Bryan M. Jenkins

*Energy Policy*, Vol. 58, pp. 381-390.

Optimal Power Flow in Microgrids with Energy Storage

Yoash Levron, Josep M. Guerrero, Yuval Beck

*I E E E Transactions on Power Systems*, Vol. 28, No. 3, pp. 3226-3234.

Discrete Displacement Hydraulic Power Take-Off System for the Wavestar Wave Energy Converter

Rico Hjerm Hansen, Morten Kramer, Enrique Vidal

*Energies*, Vol. 6, No. 8, pp. 4001-4044.

Evaluation of Fuel-Cell Range Extender Impact on Hybrid Electrical Vehicle Performance  
Hans-Christian B. Jensen, Erik Schaltz, Per Sune Koustrup, Søren Juhl Andreasen,  
Søren Knudsen Kær

*I E E E Transactions on Vehicular Technology*, Vol. 62, No. 1, pp. 50-60.

Generalized Multi-Cell Switched-Inductor and Switched-Capacitor Z-source Inverters  
Ding Li, Poh Chiang Loh, Miao Zhu, Feng Gao, Frede Blaabjerg

*I E E E Transactions on Power Electronics*, Vol. 28, No. 2, pp. 837-848.

Fuzzy Adaptive Particle Swarm Optimization for Power Loss Minimisation in Distribution  
Systems Using Optimal Load Response

Weihao Hu, Zhe Chen, Birgitte Bak-Jensen, Yanting Hu

*I E T Generation, Transmission and Distribution*, Vol. 8, No. 1, pp. 1- 10.

Wind Turbine Converter Control Interaction with Complex Wind Farm Systems

Lukasz Hubert Kocewiak, Claus Leth Bak, Jesper Hjerrild

*I E T Renewable Power Generation*, Vol. 7, No. 4, pp. 380-389.

Low Voltage Ride-Through Capability of a Single-Stage Single-Phase Photovoltaic System  
Connected to the Low-Voltage Grid

Yongheng Yang, Frede Blaabjerg

*International Journal of Photoenergy*, Vol. 2013, pp. 1-9.

Co-Optimized Design of Microchannel Heat Exchangers and Thermoelectric Generators

Alireza Rezaei Kolaei, Kazuaki Yazawa, Lasse Rosendahl, Ali Shakouri

*International Journal of Thermal Sciences*, Vol. 72, pp. 73-81.

Overview of Catastrophic Failures of Freewheeling Diodes in Power Electronic Circuits

Rui Wu, Frede Blaabjerg, Huai Wang, Marco Liserre

*Microelectronics Reliability*, Vol. 53, No. 9-11, pp. 1788-1792.

An Active Damping Technique for Small DC-Link Capacitor Based Drive System

Ram Krishan Maheshwari, Stig Munk-Nielsen, Kaiyuan Lu

*I E E E Transactions on Industrial Informatics*, Vol. 9, No. 2, pp. 848-858.

Advanced Control Architectures for Intelligent Microgrids - Part II: Power Quality,  
Energy Storage, and AC/DC Microgrids

Josep M. Guerrero, Poh Chiang Loh, Tzung-Lin Lee, Mukul Chandorkar

*I E E E Transactions on Industrial Electronics*, Vol. 60, No. 4, pp. 1263-1270.

# Key Figures



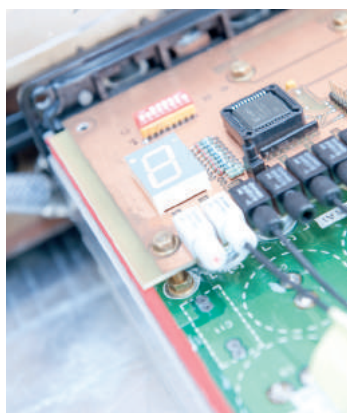
**Publications** ..... 424

## Student intake (first study year)

Aalborg undergraduate ..... 51  
 Aalborg bachelor of engineering ..... 13  
 Esbjerg undergraduate ..... 36  
 Total ..... 100

**Student intake Aalborg (Postgraduate)** ..... 40

**Student intake Esbjerg (Postgraduate)** ..... 11



## Total number of students as of October 1

Aalborg ..... 232  
 Esbjerg ..... 85  
 Total ..... 317

## Graduated students in Aalborg

Undergraduate ..... 18  
 Bachelor of engineering ..... 6  
 Postgraduate ..... 36  
 Total ..... 60

**Graduate students in Esbjerg** ..... 11



## PhD students

Graduated PhD students ..... 15  
 New PhD students ..... 28  
 Total PhD students ..... 89

**Total number of employees at the Department** ..... 185

## Turnover

Total turnover (m) ..... 133  
 External turnover (m) ..... 66

# Selected New Laboratory Facilities

## Advanced Capacitor Test System

The advanced capacitor testing system was built in 2013, supported by the Obel Funds for equipment. It enables the degradation test of capacitors under stresses up to 2000V DC voltage and 50Hz to 100 kHz 100A ripple current, and climatic conditions within -70 °C to +180 °C and 10 % to 95 % humidity. Therefore, it provides some unique opportunities to develop better degradation and lifetime models of capacitors in power electronic systems.



## TEGeta

The TEGeta equipment measures efficiency, power generation, I-V curve and heat flux through thermoelectric generators (TEGs) under high temperature conditions up to 1300 K. It can consider long term life of TEGs under practical thermal cycles. The facility consists mainly of a data logger, a PC for data acquisition, a heating plate controlled by PID controller and a coolant system. A vacuum pump and a vacuum chamber insulate the TEG from ambient air.

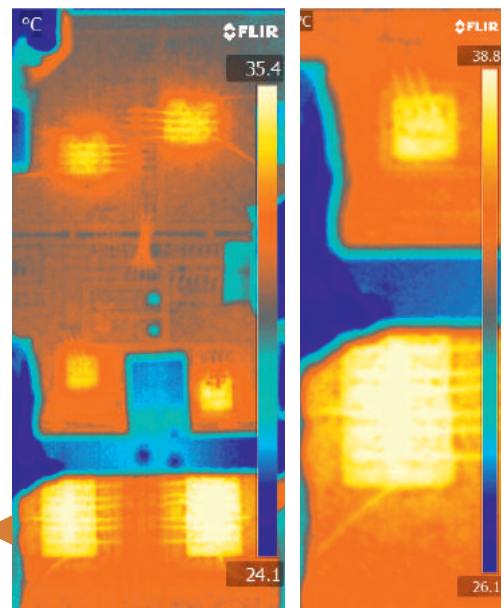


## Advanced Thermal Camera

The FLIR X8400 infrared camera provides high definition thermal video/image with +/- 1% high accuracy and 3 kHz frame rate, 1  $\mu$ s integration time. It enables investigation of the internal temperature of components, or load mapping in the whole converter system. The temperature is critical for the reliability and stress analysis of power electronic systems. The pictures show the profile of the camera and the internal temperature distribution of an IGBT module during operation.

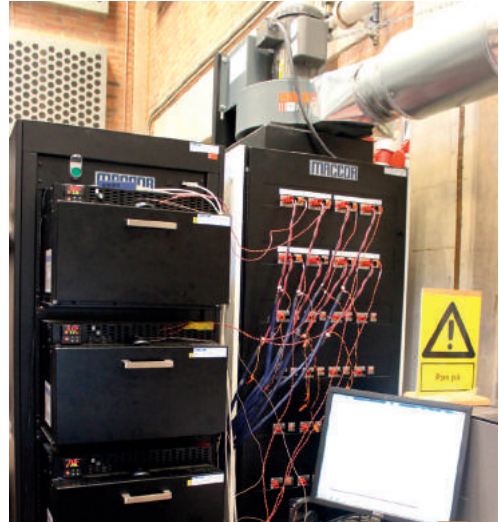
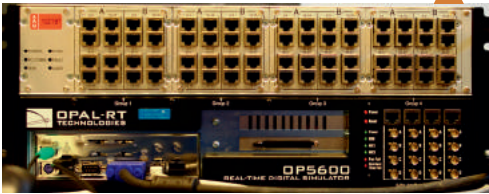


*Profile of the camera (left),  
obtained temperature  
maps (right)*



### RT-LAB in Power System – Smart Grid Lab

This particular CW Obel funding was mainly spent on RT-LAB in Power System – Smart Grid Lab. RT-LAB is a distributed real-time platform that facilitates the design process for engineering systems by taking engineers from dynamic models to real-time with hardware-in-the-loop. RT-LAB can be used to design, test and optimise control and protection systems in power grids, power electronics and motor drives. RT-LAB will be used in Power System – Smart Grid Lab to study the interactions between wind power plants and connected power systems.

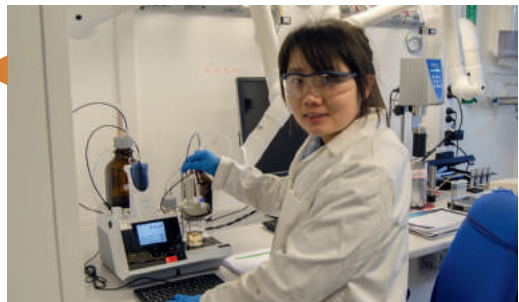


### Expansion of the Fuel Cell and Battery Laboratory

The Fuel Cell and Battery Laboratory received funding from the Obel Family Foundation for the ALPBES+ project, which includes an expansion of the experimental facilities used in battery related research. The new equipment includes a 24 channel Digatron battery test station, a dSpace Battery Emulator, a 2 channel Digatron module tester, 2 FRAs and a series of different ovens and climatic chambers. The equipment will support the expanding activities in the area of research within battery characterisation and experimental testing.

### BioOil Research Facilities

During 2013, the BioOil lab has seen significant developments. Analytical equipment including an elemental analyser, calorimeter and GC/MS has been brought online, as well as new micro-reactor types allowing very precise process control necessary for parametric studies of conversion processes. The large continuous CBS1 research facility has clocked around 200 hours on biomass feed, producing significant amounts of biocrude for further analysis and upgrading.

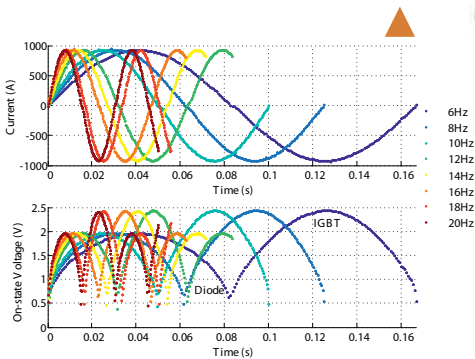


### Gurli I: An accelerated test set up for power modules in sinusoidal loading conditions

Gurli I is a DC to AC power converter with special features to test wear-out and lifetime of high power IGBT modules at sinusoidal current either in accelerated or normal loading conditions. It has ability to monitor an ageing, bond wire failures and junction temperature variations in the power module in online and offline operations inside a temperature controlled enclosure. This converter consumes 7-8kW electrical power and is equipped with a liquid cooling system.

| Parameters          | Value    |
|---------------------|----------|
| DC link voltage     | 1000V    |
| Output voltage      | 315V     |
| Inductor current    | 890Apeak |
| Output frequency    | 6Hz      |
| Switching frequency | 2.5kHz   |
| Cooling temperature | 80±1°C   |
| Room temperature    | 20±2°C   |

Converter operating parameters



Online measurement of on-state collector emitter voltage at different frequency



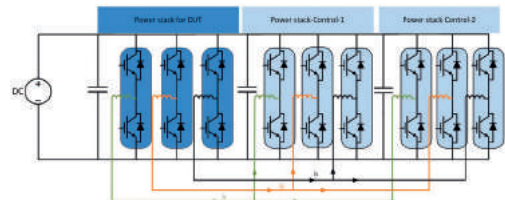
1700V, 1000A IGBT module under test



Gurli I in an enclosure

### Gurli III

Gurli III is a test platform, built under the IEPE project, to test wind turbine converters. Converters can be loaded with real world conditions, including fault ride through, or real world based accelerated test conditions to wear out the power modules. The collector emitter based estimation of the junction temperature in the power modules can be used to test the converter operating limits, indicating possibilities for power density increase.





# Awards and Honours



*Frede Blaabjerg*



*Sergio Spataru*



*Lasse Rosendahl*

## 2012 Letter Prize Award in the IEEE Transactions on Power Electronics

Professor Frede Blaabjerg was awarded with the 2012 Letter Prize Award for his letter, which was written in cooperation with colleagues from the Technical University of Catalonia in Spain. The paper discusses a new multi-level converter for power conversion which has lower costs. In 2012, the IEEE Transactions on Power Electronics published around 500 papers. 440 of these papers were regular papers and 60 papers were letters.

## Best Poster Award

At the 39th IEEE Photovoltaic Specialists Conference, PhD Fellow Sergiu Spataru received the Best Poster Award for his poster 'Development of an Intelligent Maximum Power Point Tracker Using an Advanced PV System Test Platform'. The co-authors were Anastasios Amoiridis, Remus Narcis Beres, Catalin-Iosif Ciontea, Théo Klein and Dezso Sera.

## Second Prize Award for 2012 Paper in the IEEE Transactions on Power Electronics

In 2013, Professor Frede Blaabjerg and Professor Remus Teodorescu from the Department of Energy Technology received a second prize paper award for their 2012 paper 'A Stationary Reference Frame Grid Synchronization System for Three-Phase Grid-Connected Power Converters Under Adverse Grid Conditions'. The paper was written in cooperation with colleagues from the Technical University of Catalonia and The IKERLAN Technology Research Centre in Spain.

## Award for Best Visual Presentation within the field of biomass

At the 21st European Biomass Conference and Exhibition held in Copenhagen, Denmark, Professor Lasse Rosendahl received an award for the poster 'Hydrothermal Liquefaction - HTL - of low value biomass to high value bio-crude'. The poster was made in cooperation with PhD Student Jessica Hoffmann and Assistant Professor Saqib Sohail Toor, both colleagues of Professor Rosendahl, as well as an external partner.

## Prestigious International Award for AAU Energy Professor

In 2013, Professor Frede Blaabjerg was honoured with the 2014 IEEE William E. Newell Power Electronics Award. The award is given to individuals who have made an outstanding contribution to the advancement of power electronics and is the highest award in that specific field. Professor Blaabjerg was honoured with the award for 'contributions to power electronics in renewable energy and adjustable speed drives'.

## Second Prize Award for AAU Team at International Project Competition

Ionela Florentina Grigoras and Iulia Maria Daraban, two students from the department, finished on second place in an international project competition. Their project title was 'The green oil well of the future'. A jury panel evaluated the projects for compliance with the criteria covering the following categories: problem relevance to sustainability, verification of feasibility through analysis or experimentation, quality of writing and illustrations as well as originality, feasibility and impact of concept solution.

# Selected Events



## Conference for Energy Students, CES 2013

CES is a student conference focusing on engineering subjects and is hosted by the department with the support of The Energy Sponsor Programme and EnergyVision. The conference is run in the same manner as an international conference and the goal of the conference is to give young students a chance to write scientific papers for presentation in a student forum. By participating in the conference students become familiar with writing an abstract for a scientific paper as well as the general rules for writing a conference paper.

## Annual Energy Seminar

Every year, the Energy Sponsor Programme at the department arranges an annual Energy Seminar. In 2013, the seminar was held in May together with the PhD Research Day for the first time and all the sponsors and their colleagues were invited to participate in the seminar with focus on current subjects and problems within the area of energy presented by the talents in energy technology research. On the day presentations from 42 PhD students were carried out in two parallel sessions only interrupted by a few breaks during the day.

## Presentation of the AAUdi

In May, the Department of Energy Technology was hosting a presentation of tomorrow's high-efficiency electric car integrated with the power supply system. The electric car was the visible result of a project conducted between the department and a number of companies. The car was presented at Køretekniisk Anlæg in Nørresundby where the participants could learn more about the technical solutions and obtain a test drive.

## Inauguration HTL Bio-Oil Research Facility

A generous grant from the Obel Family Foundation combined with funding from the Faculty of Engineering and Science and the Department of Energy Technology made a €1 million investment in a new continuous HTL research facility possible. The inauguration of the new HTL bio-oil research facility was celebrated in May with the visit of more prominent guests such as Connie Hedegaard, EU Commissioner for Climate Action and Ulla Astman, Governor of Northern Jutland, among others. After several inauguration speeches the event ended with a reception followed by Open lab and tours of the HTL bio-oil research facility.

## PhD Research Day

The Energy Technology PhD Research Day presentations were subdivided into two parallel sessions: One contained research related to electrical engineering and another contained research related to thermal engineering (i.e. non-electrical). These two parallel sessions had sub-sessions, which were entitled by the titles of the research programmes

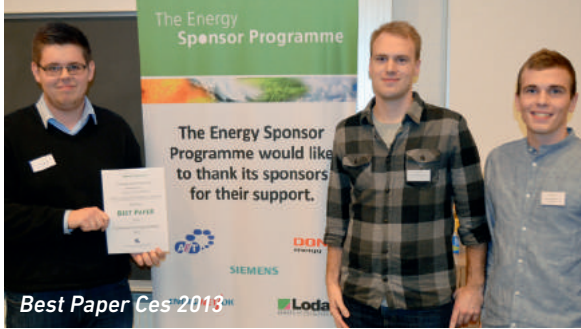


*Eco Racer Press Event*



*1st and 3rd Prize Graduation*

*Selected Events*



*Best Paper Ces 2013*



*Inauguration HTL Bio-Oil Research Facility*

at ET and chaired by the research programme leader. Each such sub-session contained 4 presentations selected from each individual research programme activities and in total 42 PhDs presented their newest research within the area of energy.

**Graduation**

In late June, the department held the yearly Graduation Ceremony for Masters graduating from Electrical Power Systems and High Voltage Engineering, Fuel Cells and Hydrogen Technology, Mechatronic Control Engineering, Power Electronics and Drives, Thermal Energy and Process Engineering and Wind Power Systems. Henrik Andersen from the Danish Energy Agency held a speech for the graduates and the Energy Band entertained before the students received their diplomas. After a cosy reception with coffee, rolls and cake, the Energy Sponsor Programme at the department handed out 1st, 2nd and 3rd prizes to the project groups demonstrating marvellous academic skill, extraordinary engagement and solid work throughout their work with the master thesis.

**Eco Racer Press Event**

In May, our Eco Racer Team participated in the Shell Eco Marathon, held in Rotterdam in the Netherlands. The Shell Eco Marathon is an annual event that challenges high school and college student teams from around the world to design, build and test energy efficient vehicles. The winners are the teams that go the farthest distance using the least amount of energy. On Tuesday April 30th the Eco Racer Team presented their two race cars to the public at a press event where the four-time DTC winner Casper Elgaard was present, giving advice to the students. Dean Eskild Holm Nielsen from the Faculty of Engineering and Science started with a short presentation on AAU and its research in energy technology followed by the Eco Racer Team's supervisor Søren Juhl Andreasen, who presented the cars to the audience.

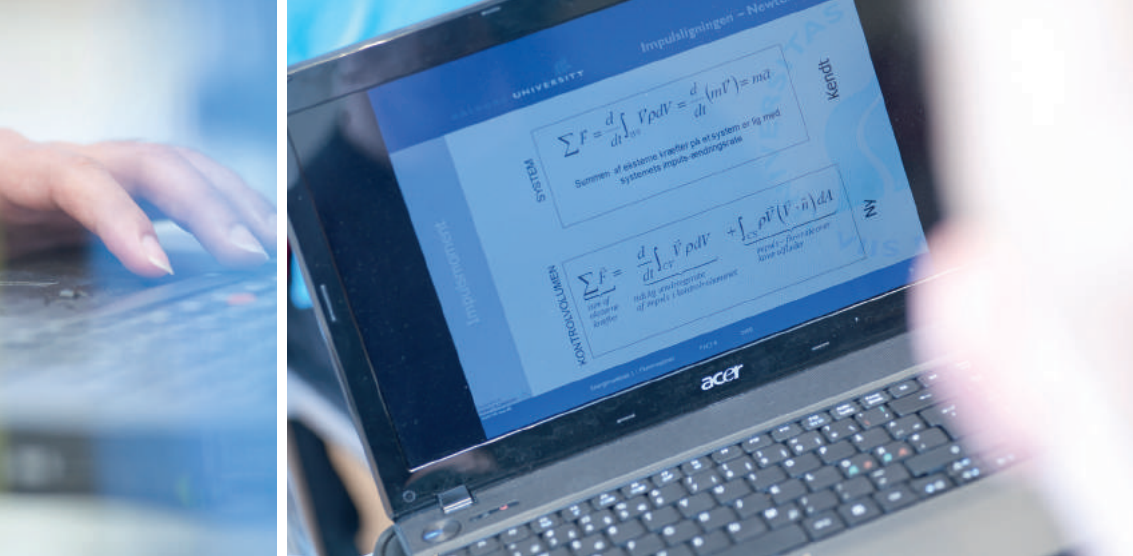
# Guests at the Department



The Department of Energy Technology receives guests on a continuous basis. This ensures good international contacts and knowledge sharing across borders. Both scientific staff and students benefit from the international environment created by the many guests as well as the knowledge these people bring to our department. Below you will find a list of guests at the department in 2013.

*For further information please visit our homepage.*

Zhanfeng Song, PhD, TianJin University, China  
Xin Zhao, PhD, Northwestern Polytechnical University, China  
Javier Roldán-Pérez, PhD, Comillas Pontifical University, Spain  
Mohammad Farhadi Kangarlu, PhD, University of Tabriz, Iran  
Shang-Hung Hu, PhD, National Sun Yat-sen University, Taiwan  
Shuheng Chen, PhD, University of Electronics Science and Technology of China  
Min Chen, Associate Professor, Zhejiang University, China  
Valerio Mariani, PhD, University of Sannio, Benevento, Italy  
Chao Yang, PhD, College of Electrical Engineering, Chongqing University, China  
Fen Tang, Post Doc, Beijing Jiaotong University, China  
Mario Petrollese, PhD, University of Cagliari, Italy  
Salah Mohamed Kamel Mohamed Hassan, PhD, University of Jaen, Spain  
Pablo José Quintana Barcia, PhD, University of Oviedo, Spain



- Yam Prasad Siwakoti, PhD, Macquarie University, Australia  
 Mehmet Dal, Associate Professor, Koaceli University, Turkey  
 Francesco Iannuzzo, Associate Professor, University of Cassino and Southern Lazio, Italy  
 Carlos Gamarra Lopez, PhD, University of Burgos, Spain  
 Said Ould Amrouche, Assistant Professor, Renewable Energy Development Center, Algeria  
 Yanjun Wang, Professor, University of Jinan, China  
 Tania Maria Garcia Sanchez, Assistant Professor, University of Castilla-La Mancha, Spain  
 Liudmila Popova, PhD, Lappeenranta University of Technology, Finland  
 Wenli Yao, Master Student, Northwestern Polytechnical University, China  
 Chandrasekaran Subramanian, PhD, University of Bologna, Italy  
 Manuel Nieves, PhD, University of Seville, Spain  
 Luis Garcia de Vicuna, Professor, Polytechnic University of Catalonia, Spain  
 Sudip Ghosh, M.Sc., University of Bordeaux, France  
 Julio Cesar Churio Barboza, PhD, University of Seville, Spain  
 Martin Ordóñez, Assistant Professor, The University of British Columbia, Canada  
 Ramon Blasco-Gimenez, PhD, Technical University of Valencia, Spain  
 Zhihui Chen, Associate Professor, Nanjing University of Aeronautics and Astronautics, China  
 Alberto Pigazo, Associate Professor, University of Cantabria, Spain  
 Lenos Hadjidemetriou, PhD, University of Cyprus  
 Xibo Yuan, Postdoc, The University of Bristol, United Kingdom

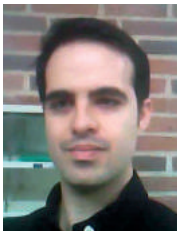
## Cases from guests in 2013



**Mohammad Farhadi Kangarlu**

"I received the B.S. and M.S. degrees (first class Hons.) both in electrical power engineering from the University of Tabriz, Iran, in 2008 and 2010, respectively, where I am currently working toward the PhD degree in electrical power engineering (power electronics and systems).

My PhD thesis title is "Improved Topologies for Cascaded Multilevel Inverters". Here at the Department of Energy Technology, I am working as a guest researcher on the "Multilevel Inverter for PV Application", supervised by Professor Frede Blaabjerg. This research aims to apply multilevel inverter as the interface of PV systems and also compare with the three-level H-bridge inverter to discover if there are some advantages. The studies also include analytical efficiency analysis of the whole system and LCL filter design."



**Javier Roldán Pérez**

"I am Javier Roldán Pérez and I come from Comillas Pontifical University in Madrid, Spain. I am a PhD guest in the Microgrid group at the Department of Energy Technology, and my supervisor is Professor Josep Maria Guerrero Zapata.

I am doing my PhD on the application of power electronics devices to improve the power quality in electrical networks, especially focused on harmonic-tracking algorithms. Currently, I am applying the algorithms that I studied in my research period in Spain to a microgrid in order to improve the power quality and to provide equal harmonic-sharing between distributed generators."

# Graduated in 2013

| Students' names         | Specialisation | Students' names            | Specialisation |
|-------------------------|----------------|----------------------------|----------------|
| Razvan Gheorghies       | PED            | Marie Cecilie Pedersen     | TEPE           |
| Dumitru-Traian-Cosmin   |                | Jess Grotum Nielsen        | TEPE           |
| Anghelus                | PED            | Sune Niemann Jensen        | TEPE           |
| Bogdan Ioan Incau       | PED            | Lars Houbak-Jensen         | TEPE           |
| Ovidiu Nicolae Faur     | PED            | Anders Holten              | TEPE           |
| Casper Vadstrup         | PED            | Ionela Grigoras            | HYTEC          |
| Csaba Kopacz            | PED            | Claus Vad                  | MCE            |
| Lórand Bede             | PED            | Anders Roland Pedersen     | MCE            |
| Sonny Sune Mads Quillo  | PED            | Dennis Bartholin Bertelsen | MCE            |
| Judit Baños Garcia      | PED            | Thomas Hammerholdt Madsen  | MCE            |
| Peter Thais Bjerregaard | EPSH           | Kasper Bitsch Lund         | MCE            |
| Ireneusz Szczesny       | EPSH           | Mathias Friis Junge        | MCE            |
| Vaclav Knap             | EPSH           | Christian Jeppesen         | MCE            |
| Sveinn Runar Juliusson  | EPSH           |                            |                |
| Bjarni Thorsteinsson    | EPSH           | In total: 36               |                |
| Egill Thorbergsson      | EPSH           |                            |                |
| Zheyuan Hu              | WPS            |                            |                |
| Rakesh Sinha            | WPS            |                            |                |
| Eloy Rodriguez Moldes   | WPS            |                            |                |
| Shaojun Huang           | WPS            |                            |                |
| Artjoms Timofejevs      | WPS            |                            |                |
| Daniel Gamboa           | WPS            |                            |                |
| Emanuel Petre-Eni       | WPS            |                            |                |
| Arsalan Hussain Zaidi   | WPS            |                            |                |

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