PhD Courses in 2016 at the Department of Energy Technology

Aalborg University

Doctoral School in Engineering and Science –

Energy Technology Programme

Denmark

Description of Doctoral Programmes at the Faculty of Engineering and Science

Short description of the programme:

The Energy Technology programme is a multi-disciplinary doctoral programme aiming at solving future challenges in the energy area by means of developing new energy technologies leading to a more efficient and sustainable management of energy. It covers a broad range of energy-related topics focusing on the energy conversion process itself as well as generation, transmission, distribution and efficient use of energy are covered. Inherently it is involving various areas of both classical and new engineering sciences as well as basic research as the physical quantity “energy” and it’s provision and use spans broadly over almost all activities a modern society faces. Electrical, thermal, mechanical, hydraulics and control engineering sciences merge in various ratios with physics and chemistry to provide front-end knowledge enabling step by step solutions to help fulfilling the climate and emission goals set by international societies. The programme is highly experimentally oriented and offers state of the art laboratory facilities. Research cooperation with both Danish and international industries is strong as well as with world class academia. The programme has hosted + 100 PhD’s for the last years and is graduating around 25 new energy technology PhD’s every year.

Research areas:

The programme belongs under The Doctoral School of Engineering and Science and focuses on:

- Power Electronics (PE) and its applications with special focus on reliability in PE. Another main focus is the interaction of PE with power systems and generation and load units.
- Electrical Power Systems including production, transmission, distribution of electrical energy as well as power quality, stability, control and protection in AC and DC systems.
- High Voltage Engineering with focus on environmentally friendly overhead lines
- Smart grid and micro grid and their application to modern societies
- Energy Efficiency as a universal term spanning the above science areas
- Renewable energy generation technologies incl. wind turbines and offshore wind power plants, photovoltaic, wave energy, thermoelectric, fuel cells and biofuels.
- Reliability, diagnosis and predictive maintenance of electrical and thermal components and systems
- Energy harvesting systems such as thermo-electric generators and systems
- Automotive and industrial drives including the design of electrical motors and generators and gears in combination with their power electronics and control.
- Systems analysis, design and optimization of a wide range of energy processes, machines and systems
- Heating/cooling systems and their distribution networks (domestic heating)
- Biomass to energy systems, including biomass to liquid fuels and end use applications
- Fluid power systems and their control
- Energy storage and power management
- Analysis and optimization of thermal cycles.

Head of Doctoral Programme, Professor Claus Leth Bak - clb@et.aau.dk

Link: http://www.et.aau.dk/phd/phd-courses/

Registration: https://phd.moodle.aau.dk/

PhD Courses 2016

No	Course	Start	End	Responsible
1	Introduction to Wind Power (Generation and Integration)	02-02-2016	05-02-2016	Zhe Chen
2	Introduction to Voltage Stability of Electric Power Systems	08-02-2016	10-02-2016	Zhe Chen
3	Thermoelectricity	22-02-2016	26-02-2016	Alireza Rezaniakolaei
4	Power Module Packaging, Failure Mechanisms, Lifetime Testing and Post Mortem Analysis	07-03-2016	09-03-2016	Stig Munk-Nielsen
5	Preparation of Research Plan for Ph.D.'s - SPRING	10-03-2016	10-03-2016	Frede Blaabjerg
6	Modelling and Control of Voltage Source Converters and AC Drives	14-03-2016	17-03-2016	Frede Blaabjerg
7	DC Microgrids	11-04-2016	13-04-2016	Josep M. Guerrero
8	AC Microgrids	14-04-2016	15-04-2016	Josep M. Guerrero
9	Power Quality in Microgrids	18-04-2016	19-04-2016	Josep M. Guerrero
10	Optimization Strategies for Energy Management Systems	20-04-2016	21-04-2016	Josep M. Guerrero
11	Biomass Resource Studies & Mapping – Conversion Technologies in Esbjerg	25-04-2016	27-04-2016	Jens Bo Holm-Nielsen
12	Understand how to write good papers for high level journals	18-05-2016	19-05-2016	Kaiyuan Lu
13	Modular Multilevel Converters MMC	31-05-2016	03-06-2016	Remus Teodorescu
14	Fundamentals of Computational Fluid Dynamics (CFD)	23-08-2016	26-08-2016	Chungen Yin
15	Dispersed Generation of Electricity	13-09-2016	16-09-2016	Birgitte Bak-Jensen
16	Stability of Modern Power Systems with High Penetration of Renewable Energy	21-09-2016	23-09-2016	Sanjay K Chaudhary
17	Preparation of Research Plan for Ph.D.'s - FALL	04-10-2016	04-10-2016	Frede Blaabjerg
18	An Introduction to HVDC and MTDC Transmission System	05-10-2016	07-10-2016	Sanjay K Chaudhary
19	Reliability in Power Electronics Systems	11-10-2016	13-10-2016	Frede Blaabjerg
20	Photovoltaic Power Systems (PVPS)	18-10-2016	21-10-2016	Dezso Sera
21	Storage Systems based on Li-ion Batteries for Grid Support and Automotive Applications	24-10-2016	27-10-2016	Remus Teodorescu
22	Harmonics in Power Electronics and Power Systems	31-10-2016	02-11-2016	Claus Leth Bak
23	Modern Power Semiconductors and their Packaging	01-11-2016	04-11-2016	Francesco Iannuzzo
24	Transients in Power Systems	14-11-2016	16-11-2016	Filipe Miguel Faria Da Silva
25	Modern Electrical Machine and Drive Systems	21-11-2016	25-11-2016	Kaiyuan Lu
26	Biomass gasification and combustion: Science and technology and modeling strategies	05-12-2016	07-12-2016	Chungen Yin

Introduction to Wind Power (Generation and Integration)

Organizer:, Professor Zhe Chen , zch@et.aau.dk, Aalborg University

Lecturers: Professor Zhe Chen, zch@et.aau.dk, Aalborg University

ECTS: 4

Time: 2 - 5 February 2016

Place: Aalborg University, Pontoppidanstræde, 9220 Aalborg East

Deadline: 19 January 2016

Max. no. of participants: 30

Description:

The course will provide training and education in the field of wind power engineering, covering the electrical aspects of wind turbine systems, including electrical machines, power electronics and power systems.

The PhD course will include basic knowledge of electrical systems of wind power conversion systems, operation and control in power systems with high level wind power penetration. Some of the course contents are based on recently obtained research results.

The main topics are as follows:

- Overview of electrical systems of wind energy conversion systems
- Wind power generators
- Power electronics in wind power conversion system
- Wind turbine systems
- Offshore wind farms and electrical system optimisation
- Operation and control of wind turbines and wind farms
- Wind turbines in power systems

Prerequisites: General knowledge in electrical engineering, preferably have a background at graduate level in electrical engineering.

Introduction to Voltage Stability of Electric Power Systems

Organiser: Professor Zhe Chen, zch@et.aau.dk, Aalborg University

Lecturer: Professor Costas Vournas, vournas@power.ece.ntua.gr, NTUA, Greece

ECTS: 4

Time: 8 - 10 February 2016

Place: Department of Energy Technology, Pontoppidanstraede, Aalborg East

Deadline: 25 January 2015

Max participants: 30

Description:

The course will provide training and education on the subject of Voltage Stability analysis.

The PhD course will include basic knowledge of power transfer limitations in DC and AC systems, the effect of reactive compensation, generator reactive support, and load dynamics and basic concepts of voltage stability monitoring, control and protection.

The main topics are as follows:

- Overview of power system stability and classification
- Basics of stability theory
- Voltage stability and maximum power transfer
- Reactive generation and reactive power limits. Immediate loss of stability
- Fast and slow response including load dynamics.
- Modelling and response of Load Tap Changers
- Multi-time scale and quasi steady state simulation
- Voltage Stability Monitoring and Countermeasures

Prerequisites: General knowledge in electrical AC circuits and electrical power engineering, preferably background at graduate level in power systems. Exercises involve Matlab.

Thermoelectricity

Organizer:	Assistant Professor Alireza Rezaniakolaei, ali@et.aau.dk, Aalborg University
Lecturers:	Professor Lasse Rosendahl, lar@et.aau.dk, Aalborg University, Professor Peter Woias, University of Freiburg, Germany, Professor Nini Pryds, Denmarks Technical University, Professor Anders Palmqvist, Chalmers University of Technology, Sweden, Assistant Professor Alireza Rezaniakolaei, Aalborg University, Associate Professor Erik Schaltz, Aalborg University, Dr. Dieter Platzek, PANCO, Germany, Dr. Ali Asghar Enkeshafi, Alpcon A/S, Denmark
ECTS:	5
Time:	22 - 26 February 2016
Place:	Aalborg University, Pontoppidanstræde, 9220 Aalborg East
Deadline:	15 February 2016
Max. no. of participants:	30

Description: The performance of thermoelectric devices is being steadily improved due to elevation of figure of merit values of the materials and also characteristics of the detailed device, optimal system designs and module fabrication techniques. The development works require a significant amount of engineering parametric analysis.

This PhD course handles the fundamentals of thermoelectric devices by introducing recent material development technics and detailed module design. This course will continue with integration principles for multilayer fluidic packaging systems and micro thermoelectric generators to increase in the output power performance of the thermoelectric module. In order to maintain a complete system optimization, efficient heat dissipation by efficient heat exchangers will be discussed. Furthermore, control of thermoelectric generators in parallel and series circuits by power electronic converters will be discussed for maximum power point tracking in thermoelectric systems. This course also addresses thermoelectric module measurements. Methods to measure the material and module characterization such as thermal expansion, surface deformation, efficiency, voltage and power generation will be discussed. The course ends with presentations of challenges and applications in thermoelectric industry by expert leading companies.

Prerequisites: Oral/Poster presentation and assignments

Preparation of Research Plan for Ph.D.'s

Organizer: Professor Frede Blaabjerg, fbl@et.aau.dk, Aalborg University

Lecturers: Professor Frede Blaabjerg, Aalborg University
Associate Professor Chungen Yin, Aalborg University

ECTS: 1

Time: 10 March 2016 or 4 October 2016

Place: Aalborg University, Pontoppidanstræde, 9220 Aalborg East

Deadline: 25 February 2016 or 20 September 2016

Max. no. of participants: 25

Description:
The objective of this 1-day PhD course is to provide a presentation on how to make a good study plan. A PhD study plan typically consists of the following sections: (1) project summary; (2) scientific content of the PhD project, including background, state-of-the-art literature review, objectives, key methods, expected outcome, time schedule and milestone, outline and structure of the PhD thesis, publication strategy and tentative titles of papers; (3) collaboration agreement between supervisor and student; (4) plan for PhD courses; (5) plan for fulfillment of knowledge dissemination; (6) agreements on immaterial rights to patents; (7) plan for external collaboration; (8) financial budget for the project; and (9) reference list. As a relatively new PhD student, it is hardly possible to give a full and clear
description of what you will do and how you will do in the coming three years. You may only have some vague ideas about your project. This course will help you to settle these problems as quickly and as well as possible via an effective literature study. A literature study is not only a potted summary of who did what. You need to find their similarities/difference, point out their contributions and flaws in methodology or gaps in research, and outline what you can utilize and what you can improve in your project. A good literature study will make your ideas about your project clearer and clearer, based on which you can start to write up your study plan, with well-defined what to do, why to do and how to do.
We will also go around different data-bases to get the latest impact research in the field by using e.g.
Web of Science, Scopus and Google Scholar.

Power Module Packaging, Failure Mechanisms, Lifetime Testing and Post Mortem Analysis

Organizer:	Professor Stig Munk-Nielsen, smn@et.aau.dk, Aalborg University
Lecturers:	Postdoc Kristian Bonderup Pedersen, kbp@nano.aau.dk, Aalborg University, Head of Department of Physics and Nanotechnology Kjeld Pedersen, kp@nano.aau.dk, Aalborg University, Associate Professor Christian Uhrenfeldt chu@et.aau.dk, Aalborg University, Associate Professor Szymon Michal Beczkowski sbe@et.aau.dk, Aalborg University and Professor Stig Munk-Nielsen, smn@et.aau.dk, Aalborg University
ECTS:	5
Time:	14 – 16 March 2016
Place:	Aalborg University, Pontoppidanstræde, 9220 Aalborg East
Deadline:	1 March 2016
Max. no. of participants:	30

Description: Power modules are the workhorse in wind, solar and drives applications. Power modules can be destroyed instantaneously, however in applications lifetimes are expected to be 20 years. Strong and the same time fragile you need to understand the power modules to design and manufacture them properly. This course bring you under the skin of power modules and introduces the multidisciplinary knowledge needed to understand packaging assembly processes, materials and layouts, as well as failure mechanisms. From the application point of view lifetime monitoring and lifetime test methods are introduced. Aging of power modules include fatigue of bond wire and soldering analysis methods are introduced.

The course is conducted by physicists and engineers with experience from the university packaging laboratory building 10kV SiC power modules and with experience of analyzing and testing industry standard power modules for higher powers.

Prerequisites: Engineers and physicists open for multidisciplinary work. The course is based on the experience and learning's assembly power modules during some years and therefore the course are intended for people who are new to the packaging of power modules. The language will be English and the academic level will be for engineers and physicist the engineers are expected to know application converters and the physicist are expected to know materials and semiconductors.

Modelling and Control of Voltage Source Converters and AC Drives

Organizer:	Professor Frede Blaabjerg, fbl@et.aau.dk, Aalborg University and Assistant Professor Xiongfei Wang, xwa@et.aau.dk, Aalborg University
Lecturers:	Professor of Power Electronics KTH Lennart Harnefors and Assistant Professor Xiongfei Wang, xwa@et.aau.dk, Aalborg University
ECTS:	4
Time:	14 – 17 March 2016
Place:	Aalborg University, Pontoppidanstraede, 9220 Aalborg East
Deadline:	31 February 2016
Max. no. of participants:	25

Description:

Voltage Source Converters (VSCs) have commonly been used with renewable power sources, flexible ac and dc power transmission or distribution systems, energy-efficient power loads, and transportation electrification. As their ever increasing penetration level in electrical grids, dynamic characterizations of VSCs are playing a critical role in building a stable and resilient power-electronic-based power system.

This course thus devotes to cover the fundamentals and state-of-the-art of modeling and control topics for VSCs in both grid-connected applications and variable speed drives.

1. Fundamentals of vector control and current control of VSCs
2. Dynamic models of induction motors and permanent-magnet synchronous motors
3. Fundamentals of sensor-less control of ac drives
4. Impedance-based modeling and stability analysis of VSCs
5. Advanced modeling techniques of VSCs for harmonic interaction and stability analysis
6. Active stabilizing techniques for VSC-fed systems

Prerequisites:

Prior knowledge of power electronics basics, pulse width modulation, and three-phase systems is preferred.

DC Microgrids

Organizer:	Professor Josep M. Guerrero, joz@et.aau.dk, Aalborg University
Lecturers:	Professor Josep M. Guerrero, Associate Professor Juan C. Vasquez, Assistant Professor Tomislav Dragicevic, Associate Professor Sanjay K. Chaudhary, Associate Professor Min Chen, PhD Student Sun Bo, PhD Student Nelson Aldana, PhD Student Enrique Diaz.
ECTS:	3
Time:	11 – 13 April 2016
Place:	Aalborg University, Pontoppidanstræde, 9220 Aalborg East
Deadline:	29 March 2016
Max. no. of participants:	20

Description: DC distribution and transmission systems are a clear trend in electrical networks. The focus of this course is on modeling, control and operation of DC Microgrids, starting with stability and control strategies analyzed in detail, DC droop, virtual impedance concepts and hierarchical control structures for DC microgrids are also introduced. Control of DC-DC and AC-DC converters oriented as DC Microgrid interfaces are evaluated. Distributed energy storage systems and nature DC output generation systems are presented showing their interaction in DC distribution Microgrids. The course also shows examples of DC microgrids in different applications like telecommunication systems or residential DC electrical distribution systems and hybrid AC-DC microgrids.

Prerequisites: Matlab/Simulink knowledge is recommended for the exercises.

Link: http://www.et.aau.dk/phd/phd-courses/

AC Microgrids

Organizer:	Professor Josep M. Guerrero, joz@et.aau.dk, Aalborg University
Lecturers:	Professor Josep M. Guerrero, Associate Professor Juan C. Vasquez, Prof. Ernane Coelho, Ph.D Student Baoze Wei, Ph.D Student Yajuan Guan.
ECTS:	2
Time:	14 - 15 April, 2016
Place:	Aalborg University, Pontoppidanstræde, 9220 Aalborg East
Deadline:	31 March 2016
Max. no. of participants:	20

Description: A Microgrid can be defined as a part of the grid with elements of prime energy movers, power electronics converters, distributed energy storage systems and local loads, that can operate autonomously but also interacting with main grid. The functionalities expected for these small grids are: black start operation, frequency and voltage stability, active and reactive power flow control, active power filter capabilities, and storage energy management. This way, the energy can be generated and stored near the consumption points, increasing the reliability and reducing the losses produced by the large power lines.
The course starts giving some examples of Microgrids in the world. The course participants not only will learn modeling, simulation and control of three-phase voltage source inverters operating in grid-connected mode and islanded mode, but also, how these power electronics converters are integrated in AC Microgrids.
Relevant concepts like frequency and voltage droop control as well as the virtual impedance concept are explained in detail. Finally this course also introduces the study of the hierarchical control of Microgrids for AC electrical distribution systems.

Prerequisites: Matlab/Simulink knowledge is recommended for the exercises.

Power Quality in Microgrids

Organizer: Professor Josep M. Guerrero, joz@et.aau.dk, Aalborg University

Lecturers: Professor Josep M. Guerrero, Aalborg University, Associate Professor Juan C. Vasquez, Aalborg University, Postdoc Mehdi Savaghebi, Aalborg University, Postdoc Francisco D. Freijedo, Aalborg University, Postdoc Lexuan Meng, Aalborg University, Assistant Lecturer Alexander Micallef, University of Malta

ECTS: 2

Time: 18 – 19 April 2016

Place: Aalborg University, Pontoppidanstræde 101, 9220 Aalborg East

Deadline: 4 April 2016

Max. no. of participants: 20

Description: Microgrids are deemed as one of the main building blocks of the smart grids; since, are able to facilitate implementation of many smart grid functions. It is expected that in a near future, smart grid emerges as a well-planned plug-and-play integration of microgrids which interact through dedicated highways for exchanging commands, data, and power. Providing a high power quality for the customers is one of the main objectives in smart grids.
On the other hand, the proliferation of different nonlinear and single-phase loads in electrical systems has resulted in voltage harmonic and unbalance as two common power quality problems. In addition, harmonic resonances can be excited giving rise to significant increase of the voltage distortion. These phenomena can cause variety of problems such as protective relays malfunction, overheating of motors and transformers and failure of power factor correction capacitors.
In this course, compensation and damping of such power quality problems will be addressed through several control approaches. The course is mainly focused on three-phase voltage source inverters, however, single-phase circuits will be also considered. The modelling and control of these power electronic converters are discussed and hierarchical and decentralized control approaches are presented in order to enhance the voltage quality. Several simulation exercises will be included in labs which cover about 50% of the course time.

Prerequisites: Matlab/Simulink knowledge is recommended for the exercises.

Optimization Strategies for Energy Management Systems

Organizer:	Professor Josep M. Guerrero, joz@et.aau.dk, Aalborg University and Associate Professor Juan C. Vasquez, juq@et.aau.dk, Aalborg University
Lecturers:	Associate Professor Moises Graells, Technical University of Catalonia, Associate Professor Eleonora Riva Sanseverino, University of Palermo, Postdoc Lexuan Meng, Aalborg University, Postdoc Amjad Anvari-Moghaddam, Aalborg University, PhD Student Adriana Luna, Aalborg University.
ECTS:	2
Time:	20 - 21 April, 2016
Place:	Aalborg University, Pontoppidanstræde
Deadline:	6 March, 2016
Max. no. of participants:	20

Description:

Energy is a resource that needs to be managed and decisions need to be made on production, storage, distribution and consumption of energy. Determining how much to produce, where and when, and assigning resources to needs in the most efficient way is a problem that has been addressed in several fields. There are available tools that can be used to formulate and solve this kind of problems. Using them in energy management problems requires starting with the basics of math programming techniques, addressing some standard production planning problems, and adapting the solutions to new particular situations of interest.

A first issue is revisiting the modelling concept. The model is a simplified and limited representation of our reality. Complex multi-level problems may need different models and models valid at the operational level (control) may not be useful at the tactical or strategic levels (scheduling and planning). Thus, when addressing energy planning problems, detailed physical models based on differential equations will be replaced by algebraic equations expressing the basic relations between lumped parameters.

Students attending the course will learn how to recognise and formulate production planning problems, and how to solve them using existing software. Since there are many powerful solvers now available, solving the problem may reduce to properly modelling it. The software GAMS will be introduced and students will use it to solve diverse planning cases during supervised hands-on sessions. The Excel Solver will be also used for illustrative and comparative purposes, and other solvers and modelling systems that are also available will be commented. The examples range from the classical transport problem to recent MILP models proposed for the optimization of energy supply chains, and they will allow discussing the choice of objective function, the representation of discrete decisions, using formulation tricks and checking the results.

The course is intended for those students that, having a general knowledge in mathematics and simulation, have a very limited experience in math optimization, programming and production management, and need to be introduced to these tools for energy systems planning and optimization.

Biomass Resource Studies & Mapping – Conversion Technologies for Bioenergy – Thermochemical and/or Biochemical Platforms

Organiser:	Associate Professor Jens Bo Holm-Nielsen, jhn@et.aau.dk, Aalborg University;
Lecturers:	Associate Professor Jens Bo Holm-Nielsen, jhn@et.aau.dk, Aalborg University and Postdoc Ane Katharina Paarup Meyer, akm@et.aau.dk, Aalborg University
ECTS:	3
Time:	25 - 27 April 2016
Place:	Aalborg University – Esbjerg Campus, Niels Bohrsvej 8, 6700 Esbjerg
Deadline:	11 April 2016
Max. no. of participants:	30

Description:

Prerequisites; Basic knowledge of resource studies and mapping of resources, Basic LCA and Socio-Economic studies, and Biomass conversion technology for energy.

Full Course Title: ***Biomass Resource Studies & Mapping – Conversion Technologies for Bioenergy – Thermochemical and/or Biochemical Platforms!***

1. Biomass resource studies and availability in the medium to long term – worldwide! – Implementing sustainability criteria's for Biomass for food – feed – fuels.
2. Case studies of Anaerobic Digestion processes and other fermentation processes. Implementation of 2. and 3. generation Biofuels systems
3. Lignocellulose materials for biofuels, front edge R&D and future considerations for 2. & 3. G biofuel production systems.
4. Biorefineries in comparison to crude oil refineries; Thermochemical and/or Biochemical platforms. Economy of Scale versus Economy of Numbers in the Bioenergy Sectors!

Understand how to write good papers for high level journals

Organiser:	Associate Professor Kaiyuan Lu, klu@et.aau.dk, Aalborg University
Lecturers:	Professor Frede Blaabjerg, fbl@et.aau.dk, Aalborg University Associate Professor Kaiyuan Lu, klu@et.aau.dk, Aalborg University
ECTS:	1.5
Time:	18 – 19 May 2016 (1.5 days)
Place:	Aalborg University, Pontoppidanstræde, 9220 Aalborg East
Deadline:	13 May 2015
Max. no. of participants:	NO

Description:

Publication in good journals is a sign of high international recognition of your work. Writing good papers that can be accepted for publication on high level journals are one of the important tasks during a Ph. D. study. This course tries to help the Ph. D. students to increase their chances to get their papers published in international journals. To serve the goal, in this course

- First, the procedure about how the paper review process is carried out will be explained (starting from the moment you submit your paper to the time that you get the reviewers' comments and until the final decision).
- How will the paper be reviewed by the reviewers.
- Standard evaluation forms that will be filled in by the reviewers for different journals.
- Important aspects to consider when you write your paper. (Paper structure, what to do and what not to do)
- How to include citations to others work in a paper
- How to write the reply-to-the-reviewers letter.
- Case study – from a rejected paper to an accepted paper.
- Exercises

Examples will be given mainly in the Energy Technology area in terms of journals – but most of it has a generic structure in terms of peer review process.

Modular Multilevel Converters MMC

Organizer:	Professor Remus Teodorescu, ret@et.aau.dk, Aalborg University
Lecturers:	Professor Remus Teodorescu, ret@et.aau.dk, Aalborg University, Associate Professor Laszlo Mathe, lam@et.aau.dk, Aalborg University, Assistant Professor Sanjay Chaudhary, skc@et.aau.dk, Aalborg University
ECTS:	4
Time:	31 May – 3 June 2015
Place:	Aalborg University, Pontoppidanstræde, 9220 Aalborg East
Deadline:	15 May 2015
Max. no. of participants:	16

Description:

MMC has been established as the technology of choice for HVDC, large utility scale STATCOM and Multil-MW drives. This course will present the fundamentals, dynamics, modelling and simulation, modulation, control and balancing as well as control under unbalanced grid. Control and operation challenges for MMC application in HVDC, STATCOM and DRIVES will be also presented. The course structure is:

Day 1: MMC fundamentals, topologies and design

Day 2: Modulation techniques (PSPWM, NLC+Sorting, Model Predictive Sorting)

Day 3: Control and balancing

Day 4 Applications of MMC (HVDC, STATCOM, DRIVES)

Around 40 % of the time will be spent in the state of the art MMC Laboratory where the course attendees can program and test 4 dspace controlled MMC setups

Prerequisites: Power Electronics, Matlab/Simulink or PLECS

Electricity Market Analytics

Organizer: Professor Zhe Chen, zch@et.aau.dk, Aalborg University

Lecturer: Professor Antonio J. Conejo, The Ohio State University - United States.

ECTS: 4

Time: 15 – 17 June 2016

Place: Aalborg University, Pontoppidanstræde, 9220 Aalborg East

Deadline: 1 June 2016

Max. no. of participants: 30

Description:

This course provides a detailed description of decision-making tools for electricity markets, addressing the perspectives of the market operator, producers, retailers, and consumers. These tools rely on stochastic optimization, and complementarity theory. The topics covered include market clearing algorithms, offering strategies for producers and stochastic producers, investment models for transmission and generation facilities and energy procurement strategies for retailers and consumers.

Topics include:

1	Electricity market organization
2	Market clearing algorithms
3	Market clearing algorithms with stochastic producers
4	Offering strategies for producers and stochastic producers
5	Investment models in production facilities
6	Transmission reinforcement and expansion planning
7	Energy procurement for retailers and consumers

Prerequisites:

Fundamentals of (i) optimization, (ii) power systems, and (iii) microeconomics.

Fundamentals of Computational Fluid Dynamics (CFD)

Organizer: Associate Professor Chungen Yin, chy@et.aau.dk, Aalborg University

Lecturers: Associate Professor Chungen Yin, Aalborg University

Postdoc Anders Christian Olesen, Aalborg University

Associate Professor Torsten Berning, Aalborg University

ECTS: 4

Time: 23 – 26 August 2016

Place: Aalborg University, Pontoppidanstræde, 9220 Aalborg East

Deadline: 9 August 2016

Max. no. of participants: 25

Description:
The objective of this 4-day PhD course is to provide a presentation on elementary computational fluid dynamics (CFD). It will provide: (1) an insight into the philosophy and power of CFD and an true understanding of the nature of the fluid dynamics equations; (2) a familiarity with finite volume method (FVM) which is the core of most in-house and commercial CFD codes, e.g., the physical meaning and in-depth understanding of the FVM, different levels of discretization, different spatial and temporal discretization schemes, assessment of the schemes, pressure-velocity coupling algorithms, under-relaxation, boundary conditions, solvers, convergence and accuracy; (3) a familiarity with flow through porous media and multiphase flow and their modeling, e.g., Lagrangian method, volume of fluid approach, mixture and Eulerian approach; (4) a familiarity with turbulent flows and their modeling, which covers Reynolds Averaged Navier-Stokes simulation, RANS (e.g., k-ε models, k-ω models, and low-Re models), scale-resolving simulations (e.g., large eddy simulation – LES, and various hybrid RANS/LES models), and near-wall modeling; (5) practices, demos and hands-on of solving relatively simple problems by programming; (6) demos of solving complicated engineering problems by using commercial CFD codes, from meshing to post-processing. As the conclusion of the course, an attendee will be well prepared to understand and follow more sophisticated state-of-the-art literature in this field, to be able to develop his or her own CFD codes using FVM to solve simple problems, and to begin the application of CFD to his or her areas of concern. This PhD course is aimed at persons who have a limited experience in this field, both recent graduates and professional engineers.

Prerequisites: Basic knowledge in fluid mechanics, multiphase flows and turbulence.

Literature: Versteeg, H.K.; Malalasekera, W. An introduction to computational fluid dynamics – The finite volume method (2nd edition). Pearson Education Limited, 2007 (ISBN 978-0-13-127498-3)

Dispersed Generation of Electricity

Organizer:	Associate Professor Birgitte Bak-Jensen, bbj@et.aau.dk, Aalborg University
Lecturers:	Associate Professor Birgitte Bak-Jensen, bbj@et.aau.dk, Aalborg University Associate Professor Florin Iov, fi@et.aau.dk, Aalborg University Associate Professor Jayakrishnan Radhakrishna Pillai, jrp@et.aau.dk, Aalborg University
ECTS:	3
Time:	13-16 September 2016
Place:	Aalborg University, Pontoppidanstræde, 9220 Aalborg East
Deadline:	30 August 2016
Max. no. of participants:	30

Description: Environmental concerns and various benefits of small on-site generation have resulted in significant penetration of dispersed generation in many distribution systems. But, this has resulted in various operational problems. This course aims to address various challenges and opportunity with having a lot of dispersed generation in a network. It focuses on the balancing, stability and reliability problems in the network together with power quality. In addition, various aspects of islanded operation of distribution systems with dispersed generation are also discussed. The course also covers the role of electric vehicles as a provider of ancillary services in the future electric power systems.

Following topics are covered in the course:

- The energy demand and supply of power.
- Power quality issues.
- Grid reconnection requirements.
- Future trends & smart grids.
- Synchronization and island detection.
- Control and operation of dispersed generation in islanded scenario.
- Electric vehicles and Power system stability.
- Impacts of electric vehicle loads on distribution network.
- Simulation tools for dispersed generation system.

Prerequisites: Electrical engineers and PhD students with knowledge about electrical power and energy systems.

Stability of Modern Power Systems with High Penetration of Renewable Energy

Organizer:	Associate Professor Sanjay K. Chaudhary, skc@et.aau.dk, Aalborg University
Lecturers:	Associate Professor Jayakrishnan Radhakrishna Pillai, jrp@et.aau.dk, Aalborg University, Postdoc Bakhtyar Hoseinzadeh, bho@et.aau.dk, Aalborg University, Associate Professor Sanjay K. Chaudhary, skc@et.aau.dk, Aalborg University
ECTS:	3
Time:	21 - 23 September 2016
Place:	Aalborg University, Pontoppidanstræde, 9220 Aalborg East
Deadline:	7 September 2016
Max. no. of participants:	30

Description:

This course deals with the stability and control of modern power systems with a high penetration of renewable energy sources.

Power system is undergoing tremendous transformation as non-conventional renewable energy sources like wind and photovoltaic are introduced. While such renewable sources are very good for the sustainable harnessing of energy, they are altering the way power system was designed to operate. First of all they are inherently stochastic in nature due to their dependence upon local weather conditions and secondly they do not use the conventional large synchronous generators. Their power electronic converter interface decouples them from the grid frequency interaction with respect to inertial response and synchronizing power. Moreover, their dependency upon weather may lead to wide variations in power generation capability. At the same time, they might not contribute to the grid frequency stability; especially if they are on maximum power point tracking control. In the event of faults, they have limited power to contribute to the short circuit currents.

On the positive side, the advances in power electronic converter controls, imparts them fast controllability. So they can be controlled to inject reactive current and assist voltage voltage stability. They may also be controlled to provide emulated inertia and primary frequency regulation provided that they have some energy storage.

Key topics include:

- Review of concepts of power system stability
- Frequency and voltage stability with a high penetration of wind and PV power
- Control opportunities and limitations provided by the converter control in RES.
- The concepts would be demonstrated through the appropriate simulation tools like PSCAD and/or DigSILENT.

Prerequisites:

A basic knowledge of modern power system.

An Introduction to HVDC and MTDC Transmission System

Organizer:	Associate Professor Sanjay K. Chaudhary, skc@et.aau.dk, Aalborg University
Lecturers:	Professor Remus Teodorecu, ret@et.aau.dk, Aalborg University and Associate Professor Sanjay K. Chaudhary, skc@et.aau.dk, Aalborg University
ECTS:	3
Time:	5 - 7 October 2016
Place:	Aalborg University, Pontoppidanstræde, 9220 Aalborg East
Deadline:	21 September 2016
Max. no. of participants:	30

Description:

This course introduces the HVDC transmission in power systems.

Line commutated converter (LCC) based High Voltage DC (HVDC) has been used worldwide for the transmission of bulk power over long distances. Voltage source converter-based HVDC (VSC-HVDC) transmission provides fast control of active and reactive power in all four quadrants. Nowadays, the concepts of multi-terminal dc (MTDC) grids interconnecting multiple energy resources and grids have been proposed.

A detailed description of the LCC-HVDC, VSC-HVDC (both using the two-level converters and the MMC-HVDC) and MTDC and their basic control schemes will be presented. The course will include lectures and simulation exercises. Simulation tools like PSCAD-EMTDC and DigSILENT will be used to demonstrate these applications.

Main topics are:

- Limitations of ac power transmission and the need for HVDC
- Classic HVDC transmission (LCC HVDC): Introduction, operation and control
- VSC-HVDC transmission for the connection of relatively weak grids, and grid connection of renewable energy sources - Introduction, operation and control
- Evolution of Modular multi-level converters (MMC) and MMC-HVDC - Introduction, operation and control
- Multi-terminal DC transmission system

Reliability in Power Electronics Systems

Organizer:	Professor Frede Blaabjerg, fbl@et.aau.dk, Aalborg University
Lecturers:	Professor Frede Blaabjerg, fbl@et.aau.dk, Aalborg University Professor Francesco Iannuzzo , fia@et.aau.dk, Aalborg University Peter de Place Rimmen, Reliability Advisor at Danfoss Power Electronics A/S, R&D Professor Giovanni Busatto, University of Cassino and Souther Lazio, Cassino, Italy Assistant Professor Huai Wang, hwa@et.aau.dk, Aalborg University Assistant Professor Ke Ma, kema@et.aau.dk, Aalborg University
ECTS:	3
Time:	11 – 13 October 2016
Place:	Aalborg University, Pontoppidanstræde, 9220 Aalborg East
Deadline:	27 September 2016
Max. no. of participants:	30

Description: The course will be the first outcome of CORPE research. The first edition of the course will focus on power devices, their modeling, the failure mechanism and health monitoring. The course will have 6 main parts: 1. Introduction to reliability and robustness approach 2. Power electronics devices physic modeling; 3. failure mechanism of devices as effect of different stressors (temperature, vibration and moisture) and physic-of-failure; 4. Real-time monitoring of power devices, prognostic methods and fault handling; 5. Analysis and design of power converters in wind and photovoltaic systems for high reliability (mission profile, comparison of topologies and semiconductor technologies, modulation and control to improve reliability); 6. Statistical analysis, industrial test procedures to improve the power converter system reliability and case studies. Accelerated Lifetime Testing (ALT) and Multi Environment Over Stress Testing (MEOST) will be also treated.

Photovoltaic Power Systems (PVPS)

Organizer:	Associate Professor Dezso Sera, des@et.aau.dk, Aalborg University
Lecturers:	Associate Professor Dezso Sera, des@et.aau.dk, Aalborg University, Associate Professor Tamas Kerekes, tak@et.aau.dk, Aalborg University, Associate Professor Laszlo Mathe, lam@et.aau.dk, Aalborg University, Postdoc Sergiu Spataru, ssp@et.aau.dk, Aalborg University
ECTS:	4
Time and Date:	18 – 21 October 2016
Place:	Aalborg University, Pontoppidanstræde, 9220 Aalborg East
Deadline:	4 October 2016
Max participants:	30

Photovoltaic is one of the most dynamically growing energy technologies in the world today. In recent years, PV has been one of the main contributors for new energy generation capacity installed, reaching a worldwide capacity of about 180 GW by the end of 2014. This fast pace of growth is expected to continue in the coming years.

The objective of this course is to give an understanding of the operation, design and control of Photovoltaic Power Systems, and to provide insight into some of the key challenges for higher penetration of photovoltaic energy into the electricity network.

The target audience are PhD students and practicing engineers but also researchers who aim to receive a comprehensive overview of modern photovoltaic systems.

The course is structured in four days, covering topics from PV panels through power electronics and their control to PV plant design and grid integration challenges. The mornings are dedicated to lectures, while the afternoons are spent with exercises.

Prerequisites: A degree in electrical engineering or control engineering and Matlab/Simulink knowledge is strongly recommended. The course language is English.

Storage Systems based on Li-ion Batteries for Grid Support and Automotive Applications

Organizer:	Professor Remus Teodorescu, ret@et.aau.dk, Aalborg University
Lecturers:	Professor Remus Teodorescu, ret@et.aau.dk, Aalborg University, Postdoc Maciej Swierczynski, mas@et.aau.dk, Aalborg University, Assistant Professor Daniel-Ioan Stroe, dis@et.aau.dk, Aalborg University, Associate Professor Erik Schaltz, esc@et.aau.dk, Aalborg University, PhD Student Jorge Varela Barreras, jvb@et.aau.dk, Aalborg University
ECTS:	3
Time:	24 - 27 October 2016
Place:	Aalborg University, Pontoppidanstræde, 9220 Aalborg East
Deadline:	3 October 2016
Participants:	20

Description:
The importance of the li-ion batteries is booming and after dominating portable electronics applications, they are entering into new sectors like grid support applications and propelling of the electric vehicles. The penetration of renewables in the power system is considered to significantly increase in near future; thus, batteries can play a crucial role in the reliable and cost efficient grid-integration of intermittent energy sources. Besides, the grid support applications, li-ion batteries have begun to play a major role in the automotive market. The use of batteries in automotive applications is a promising option in order to replace the internal combustion engine cars with ideally, zero emissions vehicles (full electric vehicles), or with controlled emission vehicles (hybrid electric vehicles and plug-in hybrid electric vehicles).
The course is divided into 3.5 days as follows:

DAY1: (Battery technologies and grid applications)
During that first day, state of the art on the energy storage technologies will be provided with special focus on the li-ion batteries. Moreover, the services that the energy storage can provide for grid applications will be discussed. This will be followed by an industrial lecturer presentation and Matlab exercise on optimal sizing of storage in different stationary applications.

DAY2: (Li-ion batteries fundamentals, testing and performance modelling)
The second day focuses on lithium ion battery technology. The operating principles, various chemistries as well as lithium ion batteries laboratory testing and performance modeling will be presented. Simulation studies in Matlab will be performed, where course participants will develop their own performance model of the Li-ion battery.

DAY3: (Automotive applications)
The third day is devoted to automotive applications. Lithium ion technologies for automotive applications will be discussed. Aspects related to li-ion battery management systems for vehicles will be covered. Moreover, sizing and control of battery powered vehicles will be addressed. Third day will be finished with the exercise on li-ion battery powered vehicle.

DAY4: (Lifetime of Li-ion batteries)
The last day is dedicated to the performance degradation and lifetime estimation of Li-ion batteries. Ageing phenomena, accelerated lifetime testing and lifetime modeling of Li-ion batteries will be covered.

Prerequisites: Basic experience in Matlab/Simulink

Harmonics in Power Electronics and Power Systems

Organizer: Professor Claus Leth Bak, clb@et.aau.dk, Aalborg University.

Lecturers: Lucian Asiminoaei - Danfoss and Lukasz Kocewiak – Dong Energy

ECTS: 3

Time: 30 October - 1 November 2016

Place: Aalborg University, Pontoppidanstræde, 9220 Aalborg East

Deadline: 16 October 2016

Max. no. of participants: 30

Description:
A 3-day intensive course “Harmonics in Power Electronics and Power Systems”. This important course provides a broad overview of power system harmonic problems, methods of analysing, measuring and effectively mitigating them. Extended simulation tools, among others DIgSILENT PowerFactory, harmonic analysis software Danfoss MCT31, Matlab/Simulink or PSpice will be used to assess and study the harmonic distortion at different points of power networks. The results of simulations will be validated in laboratory using specialized equipment, for instance GPS-synchronized measuring instruments.

Topics covered in the course are:

- Power Quality definitions. Generation mechanism of power system harmonics. Harmonic indices.

- Voltage vs. current distortion. Point of Common Coupling (PCC).

- Sources and effects of harmonic distortion.

- Harmonic measuring instruments and measuring procedures in HV and LV networks.

- Mathematical tools and theories for analysing distorted waveforms. Signal processing.

- Modelling of power system components. Harmonic analysis.

- Harmonic load-flow, frequency scan and time domain simulations.

- Software tools for harmonic analysis.

- Harmonic elimination techniques. Passive and active line filters. Filter design.

Modern Power Semiconductors and their Packaging

Organizer:	Professor Francesco Iannuzzo, fia@et.aau.dk, Aalborg University
Lecturers:	Professor Eckart Hoene, AAU and Fraunhofer IZM; Professor Francesco Iannuzzo, Aalborg University, Head of the Department of Physics and Nanotechnology Kjeld Pedersen, Aalborg University, Prof. Vladimir Popok, AAU
ECTS:	3
Schedule:	1 - 4 November 2016
Place:	Aalborg University, Pontoppidanstræde, 9220 Aalborg East
Deadline:	18 October 2016
Max. no. of participants:	20

Description: the main component of modern Power Electronics circuits is the semiconductor power switch. This course presents the fundamentals of Power Switches operations from a physical point of view, together with the specific advantages and the reason to use them in a special application.
An overview on different packaging technologies and their properties, advantages and disadvantages, is also given. Requirements from the applications and possibilities to tackle them with a semiconductor package solution will be proposed.

Part I) semiconductor theory
This part aims to give an understanding of semiconductor power switch operations. A preliminary comparison between traditional semiconductor technologies, like Silicon, and emerging technologies like GaN and SiC will begin this part. Then, an introduction to the PN junction and fundamentals of bipolar junction and field-effect transistors will be given. Successively, referring to MOSFETs and IGBTs, several details about the structure of the elementary cell will be introduced together with the explanation of the fundamental mechanisms taking place during operations, like the Miller plateau, voltage/current overshoot and voltage/current tail. An overview of abnormal operations, like unclamped inductive switching (UIS) and short circuit, together with typical unstable phenomenon like current crowding and thermal runaway, will be also given. Modern driving strategies, including two-level turn off and anti-desaturation will be also introduced.

Part II) packaging theory
This part aims to introduce, analyze and discuss packaging techniques for modern semiconductor power switches. The present challenges in terms of power density, stray inductance and resistance, and reliability issues will be broadly discussed from a physics point of view, together with several sample applications. Modern interconnection solutions will be presented together with the research challenges in the field of power electronics packaging like copper bond wires, low-profile packaging, bondless packaging, etc.

Task: the participants will be grouped and asked to team work on a real design. A final 1-day lecture is included where groups will compare and deeply discuss the achievements and the design choices.

Prerequisites: basic knowledge of circuit theory

Transients in Power System

Organizer:	Associate Professor Filipe Faria da Silva, ffs@et.aau.dk, Aalborg University
Lecturers:	Associate Professor Filipe Faria da Silva, ffs@et.aau.dk, Aalborg University
ECTS:	3
Time:	14 - 16 November 2016
Place:	Aalborg University, Pontoppidanstræde, 9220 Aalborg East
Deadline:	31 October 2016
Max. no. of participants:	20

Description:

Power systems are constantly subjected to disturbances and switching actions. These actions can be a normal connection/disconnection of a load or line, the opening of faulted areas after a short circuit, the incidence of lightning strokes on the power system, among others. These events are known as electromagnetic transients and have a short duration in the range of microseconds/milliseconds.
Even being short duration phenomena, electromagnetic transients are of fundamental importance, as the system is subjected to high currents, voltages and frequencies during those micro/milliseconds, which may damage the electrical equipment.

The participants in the course will learn how to analyse electromagnetic transients and different transient phenomena will be explored through the use of examples and theoretical explanations, as well as the respective countermeasures.
The course will also focus in the use of software tools for the simulation of the transients, more specifically EMTDC/PSCAD, which will be introduced and explained during the course. The importance of having a proper modelling of the equipment (e.g., overhead lines, underground cables, transformers, …) in function of the phenomena will be demonstrated and guidelines will be provided on how to choose the minimum modelling requirements for different transient phenomena.

Modern Electrical Machine and Drive Systems

Organizer:	Associate Professor Kaiyuan Lu, klu@et.aau.dk, Aalborg University
Lecturers:	Associate Professor Kaiyuan Lu, Aalborg University, Associate Professor Peter O. Rasmussen, Aalborg University, Associate Professor Zhenyu Yang, Aalborg University
ECTS:	5
Time:	21 – 25 November 2016
Place:	Aalborg University, Pontoppidanstræde, 9220 Aalborg East
Deadline:	7 November 2016
Max. no. of participants:	20

Description:

This is a special course combining closely the electrical machine theory with advanced control technologies for different types of electrical machines. The understanding of an electrical machine for many engineers is still a simple mathematical model represented in e.g. a dq-reference frame. This course uses several step-by-step Finite Element models to visualize the working principle and evaluate the performance of electrical machines. The link between the electromagnetic behaviors inside a machine to the well-known mathematical model can then be made straight forward. This will provide a firm understating of the electrical machine theory, and get the participants prepared for more advanced topics and various applications of electrical machines.

Based on a good understanding of electrical machines, advanced control technologies will be presented and analyzed. One of the lecturers has pure control engineering research background and will discuss how classical and modern control theory may be adopted for electrical machine control. Practical issues like nonlinear behavior of the electrical machine caused by e.g. saturation effects, and inverter voltage error effects in low-speed operation range will be well evaluated and treated properly, enabling more precise control performance. Dedicated lab facilities using dSPACE systems will be provided for the participants to implement, test, and analyze various (mainly sensorless) control technologies. The emphasis on the practical lab exercise of this course will guarantee that the participants will gain solid experience that will benefit their own work. The permanent magnet machine and synchronous reluctance machine will be the main types of machines to be discussed in this course.

It is required that the participants have basic knowledge about electromagnetic theory, dynamic modelling of electrical machines as well as classical control theory.

Electrical machine and machine control will share equally the 5 ECTS for this course.

Biomass Gasification and Combustion: Science and Technology and Modeling Strategies

Organizer:	Associate Professor Chungen Yin, chy@et.aau.dk, Aalborg University
Lecturers:	Associate Professor Chungen Yin, Aalborg University, Assistant Professor Hesameddin Fatehi, Associate Professor Matthias Mandø, Associate Professor Thomas Condra
ECTS:	3
Time:	5 – 7 December 2016
Place:	Aalborg University Esbjerg, Niels Bohrs Vej 8, Esbjerg
Deadline:	7 November 2016
Max. no. of participants:	25

Description:
As a renewable and environmentally friendly energy source, biomass and their gasification and combustion for fuel, heat and power production are gaining an increasingly important role worldwide. The objective of this PhD course is to provide a state-of-the-art presentation of the science and technology and the modelling strategies of biomass gasification and combustion. The course will cover: (1) solid biomass fuels, fuel characteristics and impacts; (2) an overview of thermochemical conversion of biomass; (3) single biomass particle combustion and gasification and the modelling; (4) biomass gasification on reactor scale: principles, key factors, reactor types and gasifier design; (5) biomass combustion technologies used in the power industries from grate-firing to suspension-firing: main characteristics, problems and solutions; (6) biomass combustion modelling: from gas-phase combustion modelling to new sub-models associated with biomass combustion and to overall modelling strategies for different biomass combustion systems (e.g., suspension-firing systems and grate-firing systems); (7) a number of demos/hands-on, e.g., modelling of single biomass gasification & combustion and CFD simulation of biomass combustion systems; (8) test and demonstration of biomass pellet combustion in a 400 kW grate-fired boiler. The course is aimed at recent graduates and professional combustion or power engineers who only have a limited experience in this field.