

## Remus Teodorescu



He received the Dipl. Ing. degree in electrical engineering from Polytechnical University of Bucharest, Romania in 1989, and Ph.D. degree in power electronics from University of Galati, Romania, in 1994. In 1998, he joined Aalborg University, Department of Energy Technology, power electronics section where he currently works as a professor. Since 2003, he is a visiting professor at Chalmers University of Technology, Gothenburg, Sweden. He has co-authored the book "**Grid Converters for Photovoltaic and Wind Power Systems**", ISBN-10: 0-470-05751-3 – Wiley and over 200 IEEE journals and conference papers. His areas of interests includes: design and control of power converters for photovoltaics and wind power systems, grid integration with wind power, HVDC/FACTS based on MMC, SiC-based converters, storage systems for utility based on Li-ion battery technology. He was the coordinator of the Vestas Power Program, 2008 – 2013.

## Maciej Swierczynski



He received his B. Tech. degree from AGH University of Science and Technology, Poland in 2005 and M. Tech degree from AGH University of Science and Technology, Poland, Cracow in 2007 in Computer Engineering for Industrial Applications and from Aalborg University, Denmark in 2009 in Power Electronics and Drives. In 2012 he completed his Ph.D. at Aalborg University, Denmark with PhD thesis: "Lithium ion battery energy storage system for augmented wind power plants". He is working currently as post-doctoral researcher at Aalborg University. His area of research is in energy storage technologies for wind applications, battery testing, modelling, and lifetime analyses.

## Daniel I. Stroe



He received the MSc degree in the field of wind power systems from the Department of Energy Technology, Aalborg University in 2010. In 2014 he received his PhD degree in "lifetime modelling of lithium ion batteries used in virtual power plant applications" from the Department of Energy Technology where he is currently working as a post-

doctoral researcher. His main research interests are in the area of renewable energy systems, energy storage systems for stationary applications and battery testing and performance-degradation modelling

## Erik Schaltz



He received the M.Sc. and Ph.D. degrees in electrical engineering from the Department of Energy Technology, Aalborg University, Aalborg, Denmark, in 2005 and 2010, respectively. From 2009 to 2012 he has been an Assistant Professor at the same department and he is currently an Associate Professor also the same place. He is the Programme Leader of the 'E-Mobility and Industrial Drives' research programme at the department. His research interests include a wide range of topics within the field of electro-mobility, e.g. power electronics, electric machines, batteries, ultracapacitors, fuel cells, battery management systems, electric and hybrid electric vehicles, power electronic reliability, thermoelectric generators, and inductive power transfer systems.

## Jorge Varela Barreras



He received a M.Sc. degree in Power Electronics and Drives from Aalborg University, Denmark, and a B.Sc. & M.Sc. degree in Electrical Engineering from University of Vigo, Spain. At the beginning of 2010, he joined Triple Solar as Photovoltaic Business Development Manager for large scale grid-connected power plants. Afterwards, he worked as Research Assistant at Department of Energy Technology. Since June 2013, he is a Ph.D. Fellow at the same department. His current research focus is on battery testing, modeling, emulation, state evaluation, diagnosis tools and Battery Management Systems.

## Lecturers

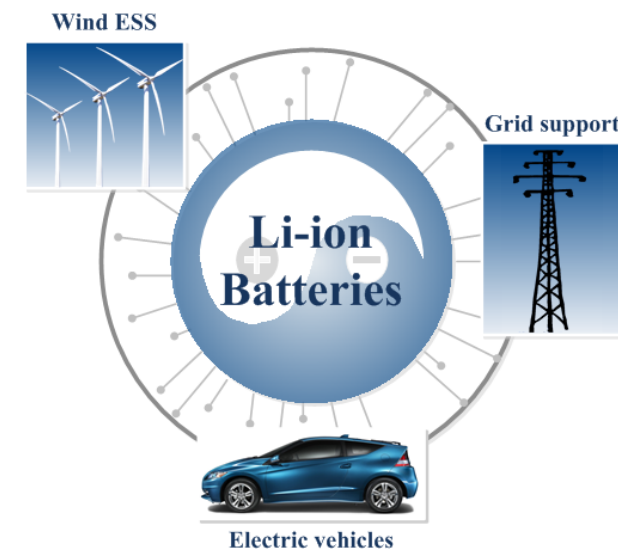
Remus Teodorescu, Professor, Aalborg University  
Maciej Swierczynski, Post-Doc, Aalborg University  
Daniel Stroe, Post-Doc, Aalborg University  
Erik Schaltz, Associate Professor, Aalborg University  
Jorge Varela Barreras, Ph.D. Fellow, Aalborg University  
Industrial Speaker, To be announced



DEPARTMENT OF ENERGY TECHNOLOGY  
AALBORG UNIVERSITY

# Industrial/Ph.D. Course in Storage Systems based on Li-Ion Batteries for Grid Support and Automotive Applications

12 – 15 October, 2015



[www.et.aau.dk](http://www.et.aau.dk)

## Background of the course

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 starts with an overview of electrochemical battery storage technologies with special focus on the lithium ion batteries. Moreover, the services that the energy storage can provide for grid applications will be discussed. This will followed by an industrial lecturer presentation and Matlab exercise on optimal sizing of storage in different stationary applications.

The second part 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.

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.

Since the feasibility of integrating Li-ion batteries in various applications is a key aspect, 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.

Keep yourself updated at [www.et.aau.dk](http://www.et.aau.dk)

## Registration

To register, you must create an account by filling out the form available at:

<https://phd.moodle.aau.dk/>

You will be ready to register for course participation, after you will receive an e-mail and confirm your registration.

Registrations close on **September 21, 2015**.

## Course Program

### Day 1: Battery Technologies and Grid Applications

08:30 Course Registration  
09:00 Overview of Electrochemical Battery Technologies  
10:00 Coffee Break  
10:30 Overview of Stationary Applications  
12:00 Lunch  
13:00 Industrial Guest Lecture  
14:30 Coffee Break  
15:00 Matlab Exercise: Optimal Sizing of Storage in Different Applications

### Day 2: Modeling of Li-ion Batteries

08:30 Li-ion Batteries: Fundamentals, Technology, Performance  
10:00 Coffee Break  
10:30 Li-ion battery testing  
12:00 Lunch  
13:00 Performance Modeling of the Li-ion Batteries  
14:30 Coffee Break  
15:00 Matlab Exercise: Performance Modeling of a Li-ion Battery

### Day 3: Automotive Applications

08:30 Battery Management in Automotive Applications  
10:00 Coffee Break  
10:30 Modeling, Sizing and Control of Battery Powered Vehicles  
12:00 Lunch  
13:00 Matlab Exercise: Battery Powered Vehicles  
14:30 Coffee Break  
15:00 Lab visit

### Day 4: Lifetime of Li-ion batteries

08:30 Ageing phenomena and degradation of the Li-ion batteries  
10:00 Coffee Break  
10:30 Ageing models of Li-ion batteries  
12:00 Lunch  
13:00 End of Course

**Language:** English

**Credits:** 3.0 ECTS

## Course Location



**Aalborg University**  
Department of Energy Technology  
Pontoppidanstræde 101  
DK-9220 Aalborg East  
Denmark

## Organization

### Further information

**Maciej Swierczynski**  
Post Doc  
Aalborg University  
Department of Energy  
Technology  
Phone +45 9940 3348  
Email: [mas@et.aau.dk](mailto:mas@et.aau.dk)

### Hotel and Transport

For hotel, transport information and booking please check: [www.et.aau.dk/phd/phd-courses](http://www.et.aau.dk/phd/phd-courses)

## Fee

The fee for the course is **11.500 DKK** for Industry, **7.500 DKK** for PhD students/ Academics outside of Denmark, and **1.500 DKK** for PhD students in Denmark.

The registration fee includes: coffee and lunch for all days, gala dinner and the course materials.

## Prerequisites

In order to be able to perform the exercises, the course participants should bring their own notebook with MATLAB software pre-installed (in case that it is not possible, some computers will be available).

## Lab facilities

- FuelCon Battery Test Station
- Maccor Battery Test Station
- Digatron Cell and Module Tester
- FuelCon Portable EIS Analyzer
- Industrial Ovens and Climatic Chambers
- Real Time Digital Simulator (RTDS)
- dSpace 32-Cell Battery Emulator

