Tutorial Proposal Form

1. Title of Tutorial

Modelling of Lithium-Ion Battery Energy Storage Systems for Grid Support Services

2. Abstract

In recent years, lithium-ion batteries have become the key energy storage technology for the e-mobility industry, because of their outstanding technical characteristics which include fast response, high power capability, and long lifetime. Consequently, due to the fast development, which was driven by the portable applications and e-mobility sectors, lithium-ion batteries have started to be more and more considered for various grid support services and for renewable’s grid integration. However, lithium-ion batteries are highly nonlinear systems and their performances are degrading in time. Therefore, in order to ensure technical and economic viability of a certain project, accurate knowledge about the behaviour of the lithium-ion battery is demanded by the industrial user for both short term operation (seconds to hours – performance modelling) and long term operation (days to years – lifetime modelling).

The objective of this tutorial is to provide the audience with an extensive overview of the lithium-ion battery energy storage technology, its operating principles, advantages and drawbacks, grid integration issues and requirements. Moreover, a large part of the tutorial is dedicated to the performance and lifetime modelling of the lithium-ion batteries. Different modelling methods will be introduced and their characteristics (e.g., accuracy, complexity etc.) will be assessed. Study cases illustrating the development and parameterization of the performance and lifetime models, based on field and extensive laboratory measurements will be presented and discussed as well.

3. Outline of Tutorial

The outline of the tutorial is as follows:

- **Lithium-ion Battery Energy Storage Systems**
  - Energy storage technologies – Overview
  - Lithium-ion batteries – Status and Challenges
  - Grid Service – Requirements for Lithium-ion batteries

- **PV Plants with (Li-ion battery) Energy Storage. An Industrial Perspective**
  - PV plants – grid integration challenges and solutions
  - PV plants with energy storage – operation and applications
  - Field experience
Performance Modelling of Lithium-Ion Batteries
- The need for performance models – requirements and challenges
- Performance modelling approaches – overview and comparison
- Electrical modelling of Lithium-ion batteries - examples

Lifetime Modelling of Lithium-Ion Batteries
- The need for lifetime models – requirements and challenges
- Lifetime modelling techniques – comparison and examples
- Accelerated lifetime tests – field measured profiles vs. synthetic laboratory profiles
- Performance-degradation modelling of Lithium-ion batteries – examples and field evaluation

4. Lead Instructor

Remus Teodorescu - ret@et.aau.dk
Department of Energy Technology, Aalborg University
Pontoppidanstræde 101, DK-9220 Aalborg, Denmark

5. Other Instructors

Pedro Rodriguez – pedro.rodriguez@abengoa.com
Abengoa Research
C/ Energía Solar nº 1, Palmas Alta
41014 Seville, Spain

Maciej Swierczynski – mas@et.aau.dk
Department of Energy Technology, Aalborg University
Pontoppidanstræde 101, DK-9220 Aalborg, Denmark

Daniel Stroe – dis@et.aau.dk
Department of Energy Technology, Aalborg University
Pontoppidanstræde 101, DK-9220 Aalborg, Denmark

6. Instructors Bios

Remus Teodorescu, (S’94, A’97, M’99, SM’02, F’12) received the Dipl.Ing. degree in electrical engineering from Polytechnical University of Bucharest, Romania in 1989, and PhD. 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 full professor. Since 2013 he is a visiting professor at Chalmers University. He has coauthored the book Grid Converters for Photovoltaic and Wind Power Systems, ISBN: 978-0-470-05751-3, Wiley 2011 and over 200 IEEE journals and conference papers. His areas
of interests includes: design and control of grid-connected converters for photovoltaic and wind power systems, 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.

Pedro Rodriguez, (S’99, M’04, SM’10, F’13) received the M.Sc. and Ph.D. degrees in electrical engineering from the Technical University of Catalonia (UPC), Spain. He was a Postdoctoral Researcher at the Center for Power Electronics Systems (CPES), Virginia Tech, Blacksburg in 2005, and at the Department of Energy Technology, Aalborg University (AAU) in 2006. He joined the faculty of UPC in 1990, where he became the Director of the research center on Renewable Electrical Energy Systems (SEER) in the Department of Electrical Engineering. He is still linked to the UPC as a part time Professor. He was also a Visiting Professor at the AAU from 2007 to 2011, acting as a co-supervisor of the Vestas Power Program. He still lectures Ph.D. courses at the AAU. He is an IEEE Fellow for his contributions on the control of distributed generation. From 2011, he is the Director of Technology on Power Systems in Abengoa.

Maciej Swierczynski, (S’09, M’12) is a postdoctoral researcher at the Department of the Energy Technology, Aalborg University, Denmark. He has two Master degrees: from AGH University of Science and Technology in Cracow (2005, Computer Engineering for Industrial Applications) and from Aalborg University, Denmark in 2009 (Power Electronics and Drives). In 2012, he received the Ph.D. degree from Aalborg University, Denmark for his work on “Lithium-ion battery energy storage system for augmented wind power plants”. During his career, he worked on several energy storage projects with research partners all over the world. His area of research is in the energy storage technologies for stationary applications, battery testing, modelling, and lifetime analyses.

Daniel Stroe, (S’07, M’14) received the Dipl.Ing. degree in electrical engineering from “Transilvania” University of Brasov, Romania in 2008, and MSc. degree in wind power systems from Department of Energy Technology, Aalborg University (AAU), Denmark, in 2000. 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, AAU 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.

Relevant Publications