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820773 - EMGE - Energy Storage

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering

Teaching unit: 709 - EE - Department of Electrical Engineering

Academic year: 2019

Degree: MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2013). (Teaching unit Optional)
MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2013). (Teaching unit Optional)

ECTS credits: 5 Teaching languages: Catalan, Spanish, English

Teaching staff

Coordinator: FRANCISCO DÍAZ-GONZÁLEZ

Others: FRANCISCO DÍAZ-GONZÁLEZ

Opening hours

Timetable: Flexible.

Prior skills

Autonomous learning capacity, mathematics, experience in simulation tools.

Teaching methodology

The following teaching methodologies are adopted for the course:

- Magistral classes or conferencies (CM): dissertations by the professor or by eventual collaborators.
- Participative classes (PART): joint discussions, as well as the resolution of exercises in the room.
- Short activities (PR): individual development (or in groups) of short activities to apply the knowledge gained in the course.
- Project (PA): knowledge based on the desing, planning and deployment of a project of relatively long extension about a particular topic and applying the knowledge gained in the subject.
- Final exam (PECC).

Learning objectives of the subject

Objectives

To gain basic knowledge on energy storage systems in electrical networks, emphasizing in electromechanical systems (flywheels, pumped-hydro installations and compressed-air installations), electric devices (supercapacitors and SMES), electrochemical systems (bateries) and chemical systems (hydrogen-based ones).

Learning results

At the end of the course, the student:

- Should know the principal characteristics of the diverse energy storage systems that can be applied in electrical networks.
- Should know the mathematical expressions (high level ones) so as to size an energy storage system from the energy demands in electrical networks.

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- Should know the management and monitoring mechanisms of energy storages.
- Should achieve a global vision of the energy storage possibilities in vehicles, with the objective of addressing the suitability of using one or another storage device according to their particular application in the network.
- Should gain capacities in modeling and simulation of energy systems including storages, as for the case of electrical networks.
- Should gain the knowledge and skills so as to define a project related to the conception, sizing and/or utilization of energy storages in electrical networks.

Study load

Total learning time: 120h	Hours small group:	30h	25.00%
	Guided activities:	10h	8.33%
	Self study:	80h	66.67%

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Content

Introduction to the power network and electrical markets

Learning time: 26h

Theory classes: 5h
Guided activities: 10h 10m
Self study : 10h 50m

Description:
Brief introduction to the operation of the power network and its associated markets, as a previous step before addressing the services the energy storage systems can provide to the network.

Related activities:
- The development of a short activity (E1), to be done individually. It should be submitted via email during the course to the professor.

Specific objectives:
- To know the mechanisms for the activation of the power reserves in electrical networks, so as to ensure the continuous balance between generation and demand.
- To understand the problems associated to the grid connection of renewable-based generating systems from the point of view of network operation.
- To know the market mechanisms associated to the activation of such power reserves.

Energy storage technologies

Learning time: 52h

Theory classes: 10h
Guided activities: 20h 20m
Self study : 21h 40m

Description:
Operating principles, characteristics, technologies available in the market, basic calculations for device sizing, description of models for simulation and evaluation of the behavior of the storages while in operation.

Related activities:
Project (PA).

Specific objectives:
To gain knowledge on diverse energy storage systems.

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Cost models for energy storage systems

Learning time: 11h

Theory classes: 2h
Guided activities: 4h
Self study : 5h

Description:
Development and application of a mathematical model so as to evaluate the costs associated to an energy storage system.

Related activities:
Project (PA).

Specific objectives:
- To know which are the main costs associated to the installation and operation of an energy storage system.
- To gain enough knowledge so as to be able to apply the cost model in a particular case.

Applications of energy storage systems in power networks.

Learning time: 16h

Theory classes: 3h
Guided activities: 6h 30m
Self study : 6h 30m

Description:
Presentation of the applications that the storages can provide in electrical systems.

Related activities:
Project (PA).

Specific objectives:
- To gain a general vision on the potential of energy storages to modernizase the electrical systems.

Regulation and business models

Learning time: 10h

Theory classes: 2h
Guided activities: 4h
Self study : 4h

Description:
Introduction to the regulatory barriers around the adoption of energy storage systems in electrical networks. Definition of potential business models.

Related activities:
Project (PA).

Specific objectives:
- To promote innovation capability of students.

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Recycling and natural resources	Learning time: 10h Theory classes: 2h Guided activities: 4h Self study : 4h

Description:
To introduce the field of battery recycling. To provide a general vision on the natural resources of strategic materials for manufacturing batteries.

Related activities:
Project (PA).

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Planning of activities

Magistral classes (CM)	Hours: 22h Theory classes: 22h
Description: To know, understand and synthetize the topics introduced by the professor or by eventual collaborators.	

Presentations (PS)	Hours: 2h Theory classes: 2h
Description: To present to the class the results obtained in the project (PA) developed individually or in groups for its evaluation.	

Tutorship (TD)	Hours: 10h Theory classes: 10h
Description: To progress in the development of the project (PA) in the room, with the help of the professor.	

Short activities (PR)	Hours: 10h Theory classes: 1h Guided activities: 9h
Description: To develop individually short activities applying the knowledge gained during the course. (Non-presential activity).	

Project (PA)	Hours: 41h Theory classes: 1h Guided activities: 40h
Description: To design, plan and deploy a project of relatively long extension about a particular topic and applying the knowledge gained in the subject.	

Self-learning (EA)	Hours: 40h Self study: 40h
Description: To study and complement the contents introduced in the course. (Non-presential activity)	

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Qualification system

Final exam (PECC), 50%
Short activities (PR), 15%
Project (PA), 35%

Regulations for carrying out activities

The use of a calculator is permitted (and needed) for the final exam (PECC). No additional documentation and any other material could be used in the exam. The short activities (PR) should be addressed individually, not in groups, and should be submitted to the professor through Atenea platform when convenient. Finally, the project (PA) is intended to be conducted either individually or in groups, and should be presented to the class during the last session for the course. The report of this project should be submitted to the professor via email.

Bibliography

Basic:

Díaz-González, F. ; Sumper, A. ; Gomis-Bellmunt, O.. Energy Storage in Power Systems. Malaysia: John Wiley and Sons, 2016. ISBN 9781118971321.