Course guide
820773 - EMGE - Energy Storage

Last modified: 16/04/2024

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 709 - DEE - Department of Electrical Engineering.

Degree: MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2013). (Optional subject).
MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Optional subject).
MASTER'S DEGREE IN ELECTRIC POWER SYSTEMS AND DRIVES (Syllabus 2021). (Optional subject).
MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2022). (Optional subject).

Academic year: 2024 **ECTS Credits:** 5.0 **Languages:** Catalan, Spanish, English

LECTURER

Coordinating lecturer: FRANCISCO DÍAZ-GONZÁLEZ

Others: FRANCISCO DÍAZ-GONZÁLEZ

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.
- 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

Type	Hours	Percentage
Hours large group	27,0	22.41
Hours small group	13,5	11.20
Self study	80,0	66.39

Total learning time: 120.5 h

CONTENTS

Introduction to the power network and electrical markets

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.

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.

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.

Full-or-part-time: 26h
Theory classes: 5h
Guided activities: 10h 10m
Self study : 10h 50m

Energy storage technologies

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.

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

Related activities:
Project (PA).

Full-or-part-time: 52h
Theory classes: 10h
Guided activities: 20h 20m
Self study : 21h 40m

Cost models for energy storage systems

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

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.

Related activities:
Project (PA).

Full-or-part-time: 11h
Theory classes: 2h
Guided activities: 4h
Self study : 5h

Applications of energy storage systems in power networks.

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

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

Related activities:
Project (PA).

Full-or-part-time: 16h
Theory classes: 3h
Guided activities: 6h 30m
Self study : 6h 30m

Regulation and business models

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

Specific objectives:
- To promote innovation capability of students.

Related activities:
Project (PA).

Full-or-part-time: 10h
Theory classes: 2h
Guided activities: 4h
Self study : 4h

Recycling and natural resources

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).

Full-or-part-time: 10h
Theory classes: 2h
Guided activities: 4h
Self study : 4h

ACTIVITIES

Magistral classes (CM)

Description:
To know, understand and synthetize the topics introduced by the professor or by eventual collaborators.

Full-or-part-time: 22h
Theory classes: 22h

Presentations (PS)

Description:
To present to the class the results obtained in the project (PA) developed individually or in groups for its evaluation.

Full-or-part-time: 2h
Theory classes: 2h

Tutorship (TD)

Description:
To progress in the development of the project (PA) in the room, with the help of the professor.

Full-or-part-time: 10h
Theory classes: 10h

Short activities (PR)

Description:
To develop individually short activities applying the knowledge gained during the course. (Non-presential activity).

Full-or-part-time: 10h
Theory classes: 1h
Guided activities: 9h

Project (PA)

Description:
To design, plan and deploy a project of relatively long extension about a particular topic and applying the knowledge gained in the subject.

Full-or-part-time: 41h
Theory classes: 1h
Guided activities: 40h

Self-learning (EA)

Description:
To study and complement the contents introduced in the course. (Non-presential activity)

Full-or-part-time: 40h
Self study: 40h

GRADING SYSTEM

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

EXAMINATION RULES.

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.

ABOUT RE-TAKE EXAM: Re-take exam is just an option for those students who did not pass the subject at the end of the course (this means getting a final mark for the subject lower than 5 points out 10 points.) In case of opting for and passing the re-take exam, the final mark for the whole subject will be 5 out 10 points.

BIBLIOGRAPHY

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