Storage in Electrical Systems

Academic Year: (2023 / 2024)

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Department assigned to the subject: Electrical Engineering Department

Coordinating teacher: GARCIA PLAZA, MANUEL

Type: Compulsory ECTS Credits : 6.0

Year : 1 Semester : 1

# REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

It is recommended that students have knowledge of electrical engineering such as: circuit theory, electrical systems and drives. It is also desirable, although to a lesser extent, that they have programming and control theory skills.

### **OBJECTIVES**

The general objective of the course is for students to acquire technical experience in energy storage projects. Specific objectives are:

- That students acquire knowledge of the different storage technologies applicable to electrical systems and specific services and applications in renewable energy plants.

- That students understand the constituent parts, control systems and operation of a storage system.
- That they be able to design the energy management system of a storage system.

- That they acquire the capacity to dimension a storage system for applications of renewable energy plants integration and services to the electricity grid.

# DESCRIPTION OF CONTENTS: PROGRAMME

1. Control devices in electrical networks: with and without energy storage systems.

- Hierarchical control of electrical systems.
- Common control devices in electrical systems.
- Modesofoperation.
- EMS market and specifications.

2. Modes of operation with accumulation systems.

- Opportunities for the application of storage systems in electrical grid.
- Description of the applications of storage systems in electrical grid.
- Energy and power applications.
- Utility perspective of storage systems in electricitygrids.
- 3. Energy storage systems in electrical networks.
  - Introduction
  - Comparison of the properties of the storage systems.
  - Storage systems description.
  - Electrochemical batteries.
- 4. Demonstration of applications in electrical networks.
  - Demonstration: Smoothing of generation slopes with storage systems.
  - Demonstration: Reduction of power peaks with storage systems.
- 5. Battery sizing.
  - Energy sizing / State of charge estimation algorithms.
  - Power sizing / Maximum power algorithms.
  - Longevity sizing / State of Health algorithms.

6. Practical exercise: Design and implementation of an application for electrical networks with energy storage systems.

## LEARNING ACTIVITIES AND METHODOLOGY

The assessment method will consist of the next activities:

- Lectures by proffesionals.
- Practical activities.
- Student presentations.
- Visit to pilot facilities.

### ASSESSMENT SYSTEM

| % end-of-term-examination/test:                                  | 0   |
|--|-----|
| % of continuous assessment (assigments, laboratory, practicals): | 100 |

Continuous assessment based on homework, laboratory practices, multiple-choice quizzes, participation and oral presentations in the classroom.

#### BASIC BIBLIOGRAPHY

- D. Andrea Battery Management Systems for Large Lithium Ion Battery Packs, Artech House, 2010

- D. Linden and T. B. Reddy Handbook of Batteries, McGraw-Hill (third ed.), 2002

- K. C. Divya and J. Østergaard Battery energy storage technology for power systems - An overview, Electric Power Systems Research, vol. 79, no. 4, pp. 511-520, Apr. 2009

- P. T. Moseley, J. Garche, C. D. Parker, and D. A. J. Rand Valve-Regulated Lead-Acid Batteries, Elsevier, Feb. 2004

- R. A. Huggins Energy Storage, first ed. ed. New York: Springer, Sep. 2010

- T. B. Reddy and D. Linden Linden's Handbook of Batteries, McGraw-Hill (fourth ed.), 2011