EE-466

# Energy storage in power systems: technologies, applications and future needs

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| Cursus | Sem. | Type |
|---|---|---|
| Electrical and Electronical Engineering | MA1, MA3 | Opt. |
| Energy Science and Technology | MA1, MA3 | Opt. |
| Energy minor | H | Opt. |

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|---|---|
| Language of teaching | English |
| Credits | 3 |
| Session | Winter |
| Semester | Fall |
| Exam | Written |
| Workload | 90h |
| Weeks | 14 |
| **Hours** | **3 weekly** |
| Courses | 2 weekly |
| Exercises | 1 weekly |
| **Number of positions** | |


## Summary

This course reviews the main energy storage technologies, their attributes, mathematical models, and applications (stationary and mobile), from design to operations and control. Battery systems, whose application and development rates today are among the most relevant, will be given special focus.


## Content

- Fundamentals of energy storage and applications
- Batteries
- Pumped-storage hydropower
- Power-to-gas
- Flywheel and compressed-air energy storage
- Mathematical models of energy storage
- Control and scheduling of energy storage
- Sizing energy storage systems
- Lab: equivalent circuit models of battery cellls
- Lab: state-of-charge estimation

## Keywords

- Energy storage
- Energy storage models
- Energy storage applications
- Battery energy storage systems (BESS)
- Control and operation of energy storage systems

## Learning Prerequisites

### Required courses

- Fundamentals of electrical circuits and systems
- Numerical and mathematical analysis

- Scientific coding
- Energy conversion

### Recommended courses

- Power electronics
- Principles of power systems

## Learning Outcomes

By the end of the course, the student must be able to:

- Understand the techniques of energy storage
- Designe correctly a storage system regarding power demand, energy content, energy efficiency
- Illustrate the mainstream energy storage technologies
- Analyze their attributes
- Analyze their performance
- Develop a control and scheduling model for energy storage systems
- Estimate the required attributes (e.g., size) for an energy storage application
- Estimate a mathematical model of a battery cell

## Transversal skills

- Make an oral presentation.
- Manage priorities.
- Use a work methodology appropriate to the task.
- Plan and carry out activities in a way which makes optimal use of available time and other resources.
- Identify the different roles that are involved in well-functioning teams and assume different roles, including leadership roles.

## Teaching methods

- Ex-cathedra teaching
- Flipped class/seminar
- Laboratories

## Expected student activities

- Review the course material proactively
- Laboratories
- Preparation of a seminar illustrating the laboratory work (in a team of 2 or 3 students)

## Assessment methods

- Seminar illustrating the laboratory work
- Written exam

## Resources

### Notes/Handbook

Notes will be distributed throughout the course.

On another note, **please note** that the schedule might be subject to minor adjustment that will be discussed at the beginning of the semester.