Universitat de Lleida

DEGREE CURRICULUM

ENERGY STORAGE

Coordination: DE GRACIA CUESTA, ALVARO

Academic year 2023-24

ENERGY STORAGE 2023-24

Subject's general information

Subject name	ENERGY STORAGE
Code	102148
Semester	2nd Q(SEMESTER) CONTINUED EVALUATION
Typology	

Degree	Course	Character	Modality
Bachelor's Degree in Energy and Sustainability Engineering	3	COMPULSORY	Attendance-based
Double bachelor's degree: Degree in Mechanical Engineering and Degree in Energy and Sustainability Engineering	3	COMPULSORY	Attendance-based

Course number of credits (ECTS)	6
Type of activity, credits, and groups	

Activity type	PRAULA	TEORIA
Number of credits	3	3
Number of groups	1	1

Coordination	DE GRACIA CUESTA, ALVARO
Department	INDUSTRIAL AND BUILDING ENGINEERING
Teaching load distribution between lectures and independent student work	40% class 60% out of class
Important information on data processing	Consult this link for more information.
Language	English
Distribution of credits	Alvaro de Gracia (5.5 ECTS) Alicia Crespo (0.5 ECTS)

ENERGY STORAGE 2023-24

Teaching staff	E-mail addresses	Credits taught by teacher	Office and hour of attention
DE GRACIA CUESTA, ALVARO	alvaro.degracia@udl.cat	3,6	
ORÓ PRIM, EDUARD	eduoro@diei.udl.cat	3,6	

Subject's extra information

The course presents and analyses the different available energy storage technologies, including electrical, mechanical and thermal storage.

It is **COMPULSORY** that the students bring the following elements of individual protection (EPI) to the practices at the laboratory.

- Blue laboratory gown from UdL (unisex)
- Protection glasses
- Mechanical protection gloves

They can be purchased through the shop Údels of the UdL:

C/ Jaume II, 67 baixos
Centre the Cultures i Cooperació Transfronterera

http://www.publicacions.udl.cat/

The use of other elements of protection (for example caps, masks, gloves of chemical or electrical risk, etc.) will depend on the type of practice to be done. In that case, the teacher will inform of the necessity of specific EPI.

Not bringing the EPI's described or not fulfilling the norms of general security that are detailed below imply that the student can not access to the laboratories or have to go out of them. The no realisation of the practices for this reason imply the **consequences in the evaluation** of the subject that are described in this course guide.

GENERAL NORMS OF SECURITY IN LABORATORY PRACTICES

- Keep the place of realisation of the practices clean and tidy. The table of work has to be free from backpacks, folders, coats...
- No short trousers or short skirts are allowed in the laboratory.
- Closed and covered footwear is compulsory in the laboratory.
- Long hair needs to be tied.
- Keep the laboratoy gown laced in order to be protected from spills of chemicals.
- Bangles, pendants or wide sleeves are not allowed as they can be trapped.
- Avoid the use of contact lenses, since the effect of the chemical products is much bigger if they enter between the contact lense and the cornea. Protection over-glasses can be purchased.
- No food or drink is allowed in the laboratory.
- It is forbidden to smoke in the laboratories.

- Wash your hands whenever you have contact with a chemical product and before going out of the laboratory.
- Follow the instructions of the teacher and of the laboratory technicians and ask for any doubt on security.

For further information, you can check the following document of the *Servei de Prevenció de Riscos Laborals de la UdL*: http://www.sprl.udl.cat/alumnes/index.html

Learning objectives

GENERAL OBJECTIVES OF THE COURSE

To provide knowledge, tools and habilities to develop efficiently the professional tasks related to energy storage.

This general objective will be achieve by:

- To know and understand basic thermodynamic and heat transfer concepts
- To know energy storage concepts and its implementation in different sectors
- To analyze electrical energy storage systems and its applications
- To analyze mechanical energy storage systems and its applications
- To analyze thermal energy storage systems and its applications

Competences

Basic Competences (Annex I section 3.3 of Royal Decree 861/2010)

- CB2. That students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and the resolution of problems within their area of study.
- CB3. That students have the ability to gather and interpret relevant data (usually within their area of study) to make judgments that include a reflection on relevant issues of a social, scientific or ethical nature.
- CB5. That the students have developed those learning skills necessary to undertake further studies with a high degree of autonomy.

General Competences according to Order CIN / 311/2009 and EPS criteria

- CG7. To have knowledge in applied thermodynamics and heat transfer, basic principles, and its application in solving engineering problems
- CG10. To have knowledge and use the principles of theory circuits and electrical machines.
- CF11. To have knowledge about basic electronics.
- CG12. To have knowledge about the fundamentals of automatisms and control methods.

Specific Competences according to Order CIN / 311/2009

- CE12. To have applied knowledge about renewable energies.
- CE15. To acquire the ability to understand, interpret and apply the legislation on energy and environment.
- CE18. To acquire the ability to calculate and design energy storage systems

Transversal Competences approved by the Plenary Committee of the Degrees of Industrial Engineering, Computer Engineering and Building Engineering, meeting on June 16, 2008

- CT2. Master a foreign language, especially English.
- CT5. Acquire basic knowledge on scientific thinking.

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Subject contents

•Chapter 1. Introduction to Energy Storage

•Chapter 2. General Thermodynamics

•Chapter 3. Mechanical Energy storage.

•Chapter 4. Thermal energy storage systems

•Chapter 5. Compressed air energy storage systems

•Chapter 6. Electrochemical energy storage

•Chapter 7. Hydrogen for energy storage

•Chapter 8. Supercapacitors for energy storage

Methodology

The methodological axes of the subject will be divided into:

• Lectures: Lectures are taught orally by the teacher without the active participation of the students.

• Problem solving: In the problem-solving activity, teachers present a complex issue that students must solve, whether working individually or in a team.

• Group work: Learning activity that must be done through collaboration between the members of a group.

• Laboratory: They allow to apply and configure, at a practical level, the theory of a field of knowledge in a specific context.

Development plan

The development plan will follow the contents. This plan can be modified during the course according to the number of students of the evolution of the group. All classes will be imparted by professor Alvaro de Gracia.

Week	Methodology	Topic	Hours at class	Hours out of class
1	Master class	Introduction and presentation of the course	2	3
1-2	Master class and problems resolution	Introduction to energy storage	6	9
3-4	Master class and problems resolution	Basics thermodynamics	6	9
4-5	Master class and problems resolution	Mechanical energy storage	6	9
6-7	Master class and problems resolution	Thermal energy storage	6	9
8	Master class and problems resolution	Energy storage based on compressed air systems	4	6
9		Written exam	2	3

10-13	Master class and problems resolution	Electrochemical energy storage	14	21
13-14	Master class and problems resolution	Energy storage based on hydrogen	4	6
14-15	Master class and problems resolution	Energy storage based on supercapacitors	4	6
16-17		Written exam	2	3
19		Written exam - Recovery	2	3

Evaluation

Block 1. Written exam. Chapters 1, 3, 4 and 5 (E1) 40%

Block 2. Written exam. Chapters 6,7 and 8 (E2) 40%

Block 3. Project about implementation of an energy storage system (P) 20%

Course mark before recovery = 0.4*E1+0.4*E2+0.2*P

There will be a recovery examen (R) with the contents of E1 and E2 with a weight of 80% of the course.

Course mark if recovery = 0.8*R+0.2*P

Alternative Evaluation: Exam with all contents of the course (100%)

Bibliography

1. Energy Storage: Systems and Components

1st Edition

Author: Alfred Rufer

ISBN 9781138082625

2. Engineering Energy Storage

1st Edition

Authors: Odne Stokke Burheim

ISBN: 9780128141007