



## Course guide

### 295114 - 295II134 - Fuel Cells

Last modified: 10/07/2024

**Unit in charge:** Barcelona East School of Engineering  
**Teaching unit:** 713 - EQ - Department of Chemical Engineering.

**Degree:** MASTER'S DEGREE IN INTERDISCIPLINARY AND INNOVATIVE ENGINEERING (Syllabus 2019). (Optional subject).  
ERASMUS MUNDUS MASTER IN HYDROGEN SYSTEMS AND ENABLING TECHNOLOGIES (HYSET) (Syllabus 2024). (Optional subject).

**Academic year:** 2024    **ECTS Credits:** 6.0    **Languages:** English

#### LECTURER

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**Coordinating lecturer:** NÚRIA JIMÉNEZ DIVINS  
LLUIS SOLER TURU

**Others:** Soler Turu, Lluís  
Burgues Ceballos, Ignasi  
Prieto De La Parte, David  
Jiménez Divins, Núria

#### PRIOR SKILLS

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Basic knowledge of thermodynamics and chemical engineering

#### REQUIREMENTS

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#### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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**Specific:**

CEMUEII-13. Design industrial applications that use physical-chemical processes that optimize the efficiency and sustainability of the systems. (Specific competence of the Efficient Systems specialty).

**General:**

CGMUEII-01. Participate in technological innovation projects in multidisciplinary problems, applying mathematical, analytical, scientific, instrumental, technological and management knowledge.

CGMUEII-05. To communicate hypotheses, procedures and results to specialized and non-specialized audiences in a clear and unambiguous way, both orally and through reports and diagrams, in the context of the development of technical solutions for problems of an interdisciplinary nature.

**Transversal:**

05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.

06 URI. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.

03 TLG. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.



## TEACHING METHODOLOGY

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Classroom. Self-study. Learning from projects and study cases

## LEARNING OBJECTIVES OF THE SUBJECT

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Learn the basic thermodynamics, physics, chemistry and electrochemistry principles that govern fuel cell and hydrogen technologies  
Learn the existing fuel cell types and main attributes and applications for stationary power and mobility  
Understand the economics, challenges and opportunities for their commercialization in the industrial sector  
Knowledge of advanced applications such as carbon capture, polygeneration and energy storage with fuel cells  
Understand the environmental, sustainability and energy security impacts of fuel cell and hydrogen technologies

## STUDY LOAD

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Type	Hours	Percentage
Hours large group	21,0	14.00
Hours small group	21,0	14.00
Self study	108,0	72.00

**Total learning time:** 150 h

## CONTENTS

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### Introduction to fuel cell technologies

**Description:**

Description of fuel cell principles. Types of fuel cells and applications for the electricity, mobility and portable sectors. Hydrogen technologies: production, storage and transportation

**Specific objectives:**

To understand how fuel cells work. To identify which type of fuel cell type is better for each application. To learn the basic principles of hydrogen technologies

**Related activities:**

Patents and peer-reviewed articles search and analysis

**Full-or-part-time:** 45h

Theory classes: 15h

Self study : 30h



### Advanced fuel cell applications

**Description:**

Economic analysis of fuel cell systems. Carbon capture and polygeneration of electricity, hydrogen and water with carbonate fuel cells (MCFC). Energy storage and power-to-gas (P2G) with proton-exchange membrane (PEM) and solid oxide (SOFC) fuel cells and electrolyzers

**Specific objectives:**

To be able to include fuel cell and hydrogen technologies to decarbonize a specific industrial sector and analyze the economic and environmental impacts. To evaluate advanced energy storage solutions with hydrogen and fuel cell technologies to allow higher penetrations of renewable energy to the electric grid

**Related activities:**

Learn about the European Union research and innovation financing program Horizon 2020. Selection and evaluation of one existing project related with fuel cells or hydrogen technologies

**Full-or-part-time:** 54h

Theory classes: 18h

Self study : 36h

### GRADING SYSTEM

50% written exam and 50% (practicum + group project)

### EXAMINATION RULES.

Written exams are individual. A group project will be evaluated with a final report. The laboratory practicum is mandatory

### BIBLIOGRAPHY

**Basic:**

- National Energy Technology Laboratory (Estats Units d'Amèrica). Fuel cell handbook. 7th ed. Virginia: National Energy Technology Laboratory, [2016]. ISBN 9781365101137.

**Complementary:**

- O'Hayre, Ryan P [et al.]. Fuel cell fundamentals. 3rd ed. Hoboken: John Wiley and Sons, [2016]. ISBN 9781119113805.

- Barbir, Frano. PEM fuel cells : theory and practic [on line]. Amsterdam ; London: Elsevier Academic, 2005 [Consultation: 13/09/2024]. Available on: [https://discovery.upc.edu/permalink/34CSUC\\_UPC/rdgucl/alma991002901819706711](https://discovery.upc.edu/permalink/34CSUC_UPC/rdgucl/alma991002901819706711). ISBN 0120781425.

- Jiang, San Ping; Li, Qingfeng. Introduction to fuel cells : electrochemistry and materials [on line]. Gateway East, Singapore: Springer, 2022 [Consultation: 13/09/2024]. Available on: [https://discovery.upc.edu/permalink/34CSUC\\_UPC/rdgucl/alma991005066966106711](https://discovery.upc.edu/permalink/34CSUC_UPC/rdgucl/alma991005066966106711). ISBN 981-10-7626-X.

### RESOURCES

**Other resources:**

Notes from class and other documents from the Digital Campus