Course guide
820748 - HPC - Hydrogen and Fuel Cells

Last modified: 01/07/2025

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 713 - EQ - Department of Chemical 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 ENERGY ENGINEERING (Syllabus 2022). (Optional subject).

Academic year: 2025 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Soler Turu, Lluis

Others: Soler Turu, Lluis
Prieto de la Parte, David
Jiménez García, Núria
Burgues Ceballos, Ignasi

PRIOR SKILLS

Basic knowledge on chemical engineering

REQUIREMENTS

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DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEMT-1. Understand, describe and analyse, in a clear and comprehensive manner, the entire energy conversion chain, from its status as an energy source to its use as an energy service. They will also be able to identify, describe and analyse the situation and characteristics of the various energy resources and end uses of energy, in their economic, social and environmental dimensions, and to make value judgments.
CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.
CEMT-6. Employ technical and economic criteria to select the most appropriate electrical equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technology applications in the field of production, transport, distribution, storage and use of electric energy.
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.

TEACHING METHODOLOGY

- Lectures and conferences: knowledge exposed by lecturers or guest speakers.
- Participatory sessions: collective resolution of exercises, debates and group dynamics, with the lecturer and other students in the classroom; classroom presentation of an activity individually or in small groups.
- Theoretical/practical supervised work: classroom activity, carried out individually or in small groups, with the advice and supervision of the teacher.
- Homework assignment of reduced extension: carry out homework of reduced extension, individually or in groups.
- Homework assignment of broad extension (PA): design, planning and implementation of a project or homework assignment of broad extension by a group of students, and writing a report that should include the approach, results and conclusions.

LEARNING OBJECTIVES OF THE SUBJECT

- To develop technical criteria to define an energy system with the participation of a fuel cell from chemical, biological, catalytic, material, heat transfer and energy and materials flow data.
- To develop scientific and technical skills to obtain and manipulate hydrogen for their use in fuel cells and to set up the basis for their implementation, optimization and/or modification.
- To identify the problems and weaknesses of energy systems and electrical devices and to provide engineering solution.
- To develop scientific skills to develop new ideas related to the hydrogen energy vector and fuel cells.

STUDY LOAD

Type	Hours	Percentage
Hours large group	45,0	34.62
Self study	85,0	65.38

Total learning time: 130 h

CONTENTS

Hydrogen production technologies

Description:
Hydrogen as an energy vector. Hydrogen production from fossil and renewable substrates. Hydrogen obtention by (i) electrolysis, (ii) catalytic reforming, (iii) termochemical cycles, (iv) photocatalytic methods and (v) biological methods. Separation and purification of hydrogen.

Specific objectives:
To know the fundamentals and utility of hydrogen as an energy vector and to learn the technology basis of its obtention from several substrates and by different methods.

Related activities:
Analysis of a device for producing hydrogen and its use in fuel cells.

Related competencies :
CEMT-6. Employ technical and economic criteria to select the most appropriate electrical equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technology applications in the field of production, transport, distribution, storage and use of electric energy.
CEMT-1. Understand, describe and analyse, in a clear and comprehensive manner, the entire energy conversion chain, from its status as an energy source to its use as an energy service. They will also be able to identify, describe and analyse the situation and characteristics of the various energy resources and end uses of energy, in their economic, social and environmental dimensions, and to make value judgments.
CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.

Full-or-part-time: 47h
Theory classes: 12h
Guided activities: 5h
Self study : 30h

Hydrogen storage and transportation

Description:
Physical methods for storage (compresswion, liquefaction, microspheres, physisorption, carbon nanostructures, etc.). Chemical methods for storage (quimisorption, metallic hydrides, non-metallic compounds, etc.). Hydrogen transportation. In situ, on-demand hydrogen production.

Specific objectives:
To acquire knowledge related to the management and transport of the hydrogen vector. To know the main methods of storage and be able to establish criteria for the selecting of the most appropriate for a particular application.

Related activities:
Analysis of a hydrogen production system and its use in fuel cells.

Related competencies :
CEMT-6. Employ technical and economic criteria to select the most appropriate electrical equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technology applications in the field of production, transport, distribution, storage and use of electric energy.
CEMT-1. Understand, describe and analyse, in a clear and comprehensive manner, the entire energy conversion chain, from its status as an energy source to its use as an energy service. They will also be able to identify, describe and analyse the situation and characteristics of the various energy resources and end uses of energy, in their economic, social and environmental dimensions, and to make value judgments.
CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.

Full-or-part-time: 32h
Theory classes: 7h
Guided activities: 5h
Self study : 20h

Fuel cells

Description:
Basics of fuel cells, general characteristics and types. Parts of a fuel cell: electrolytes, electrodes, bipolar plates, etc. Use of fuel cells in (i) stationary applications, (ii) transport applications and (iii) portable applications and electronics.

Specific objectives:
Basics of fuel cells, general characteristics and types. Parts of a fuel cell: electrolytes, electrodes, bipolar plates, etc. Use of fuel cells in (i) stationary applications, (ii) transport applications and (iii) portable applications and electronics.

Related activities:
Analysis of a hydrogen production system and its use in fuel cells.

Related competencies :
CEMT-6. Employ technical and economic criteria to select the most appropriate electrical equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technology applications in the field of production, transport, distribution, storage and use of electric energy.
CEMT-1. Understand, describe and analyse, in a clear and comprehensive manner, the entire energy conversion chain, from its status as an energy source to its use as an energy service. They will also be able to identify, describe and analyse the situation and characteristics of the various energy resources and end uses of energy, in their economic, social and environmental dimensions, and to make value judgments.
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.

Full-or-part-time: 46h
Theory classes: 11h
Guided activities: 5h
Self study : 30h

ACTIVITIES

Analysis of a hydrogen production system and its use in fuel cells.

Description:
Using the tools learned in class and the scientific and technical information available in articles and patents to propose an energy system based on hydrogen and fuel cells.

Specific objectives:
Dealing with articles and patents; evaluation of different methods of hydrogen production in different environments; application study of a fuel cell.

Material:
Problem statement and scientific and technical documentation that will be available in the digital campus.

Delivery:
Report and solutions of the activity with the methodology and references used.

Related competencies :
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CEMT-6. Employ technical and economic criteria to select the most appropriate electrical equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technology applications in the field of production, transport, distribution, storage and use of electric energy.
CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.

Full-or-part-time: 65h
Guided activities: 15h
Self study: 50h

GRADING SYSTEM

Exam (PE): 50 %
Homework (TR): 50 %

EXAMINATION RULES.

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BIBLIOGRAPHY

Basic:
- Llorca, Jordi. El Hidrógeno y nuestro futuro energético [on line]. Barcelona: Universitat Politècnica de Catalunya, 2010 [Consultation: 15/04/2025]. Available on: https://upcommons.upc.edu/handle/2099.3/36579. ISBN 9788498804188.

Complementary:
- Busby, Rebecca L. Hydrogen and fuel cells : a comprehensive guide. Tulsa, Okla.: PennWell Corp, cop. 2005. ISBN 9781593700430.
- Hoffmann, Peter. Tomorrow's energy : hydrogen, fuel cells, and the prospects for a cleaner planet [on line]. Revised and expanded ed.. London: MIT Press, 2012 [Consultation: 16/05/2025]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=3339

385. ISBN 9780262516952.
- San Ping Jiang, Qingfeng Li. Introduction to fuel cells: electrochemistry and materials [on line]. Springer Nature Singapore Pte Ltd, 2022 [Consultation: 09/07/2024]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-981-10-7626-8. ISBN 978-981-10-7626-8.

RESOURCES

Other resources:
Notes from class and other documents from the Digital Campus