



## Course guide

# 820737 - EEEURE - Energy Efficiency and Rational Use of Energy

**Last modified:** 10/07/2024

**Unit in charge:** Barcelona School of Industrial Engineering  
**Teaching unit:** 709 - DEE - Department of Electrical Engineering.  
724 - MMT - Department of Heat Engines.

**Degree:** MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2013). (Compulsory subject).  
MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2022). (Compulsory subject).

**Academic year:** 2024    **ECTS Credits:** 5.0    **Languages:** English

### LECTURER

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**Coordinating lecturer:** Rigola Serrano, Joaquim

**Others:** Monjo Mur, Lluís  
Kizildag, Deniz

### PRIOR SKILLS

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- Fundamentals of thermodynamics.
- Fundamentals of electrical engineering

### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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**Specific:**

CEMT-9. Undertake projects related to energy management in production and service sectors, recognise and value advances and developments in the field and contribute innovative ideas.

**Transversal:**

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

## TEACHING METHODOLOGY

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The course teaching methodologies are as follows:

- Lecture or conference (EXP): exposure of knowledge by teachers or through invited conferences.
- Problem solving and case studies (RP): 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.
- Laboratory / Workshop (L / F): performing of designs, measurements, verifications, etc., And presentation of results orally or in writing, either individually or in small groups.
- Theoretical/practical supervised work (TD): classroom activity or exercise of theoretical or practical contents, carried out individually or in small groups, with the advice and supervision of the teacher.
- Project, activity or homework assignment of limited scope (PR): learning based in the assignment, carried out individually or by a group of students, which must apply knowledge and present results.
- Project or homework assignment of broad scope (PA): learning based on the design, planning and implementation of a project or homework assignment of wide complexity or length by a group of students, which must apply and expand their knowledge, also write a report that must include the project approach, results and conclusions.

Training activities:

The course training activities are as follows:

Face to face activities

- Theoretical classes and conferences (CTC): to know, understand and synthesize the knowledge presented by the teacher or external lecturers.
- Practical classes (CP): to participate in the collective resolution of exercises, as well as in discussions and group dynamics, with the lecturer and other students in the classroom.
- Presentations (PS): to present in the classroom an activity individually or in small groups.
- Laboratory / Workshop (L / T): understanding the operation of equipment, specification and documentation; make designs, measurements, verifications, etc., and present the results orally or in writing individually or in small groups.
- Tutorials of practical or theoretical works (TD): to perform an activity in the classroom, or a theoretical or practical exercise, individually or in small groups, with the advice of the teacher.

Study activities

- Carry out a project, activity or work of reduced scope (PR): to carry out, individually or in a group, of a homework assignment of reduced complexity or scope, applying knowledge and presenting results.
- Carry out a project or comprehensive work (PA): design, plan and carry out, individually or in a group, a project or task of wide complexity or length, applying and extending knowledge, and writing a report that should include the approach, results and conclusions.
- Self-study (EA): to study or to expand the contents of the learning material, individually or in groups, understanding, assimilating, analysing and synthesizing knowledge.

## LEARNING OBJECTIVES OF THE SUBJECT

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### Objetives

The field of the course corresponds to energy efficiency and the rational use of energy. In this area it is intended that students acquire the knowledge and skills necessary for diagnosis and for calculating the energy efficiency of equipment and services as well as for the design and implementation of energy saving measures and the improvement of energy efficiency in different sectors: domestic, productive, and services.

### Learning Outcomes

At the end of the course, the student:

- Is able to describe the role of energy management, energy efficiency and energy savings in the context of global and regional energy systems, their economic, social and environmental connotations, and the impact of the associated technologies in local and global contexts.
- Is able to describe the relevant organizations, major projects at the international level, the main sources of information and regulations concerning the management and efficient use of energy in the different sectors.
- Has the elements of analysis and knowledge necessary to carry out projects and consultancies related to the management and efficient use of energy in different sectors.
- Is able to propose transferable results to improve management and efficient use of energy, by developing new ideas.

## STUDY LOAD

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Type	Hours	Percentage
Self study	80,0	64.00
Hours large group	45,0	36.00

**Total learning time:** 125 h

## CONTENTS

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### 1. Introduction

#### Description:

Course presentation. Basic concepts.

Overview of the different content of the course. Course planning and evaluation methodology. Basic concepts of energy efficiency, energy saving and rational use of energy

#### Specific objectives:

To introduce students to the basic concepts of energy efficiency, energy saving and rational use of energy

#### Full-or-part-time: 6h

Theory classes: 2h

Self study : 4h

## 2. Energy Audits & Diagnostics

### Description:

Energy Efficiency. Demand Side Management. Rational Use of Energy. Energy audits.

Diagnosis of Energy. Energy audits: General illustrative case of implementation; examples. Energy balances. Energy availability. Thermo-economy. Application example.

### Specific objectives:

Develop students' abilities to apply previous knowledge and basic concepts in the practice for energy audits.

Develop students' skills in data processing and analysis of experimental results.

### Related activities:

1. Refrigeration and air conditioning cycles and heat exchangers (HVAC & R). Heat pump water heater

### Related competencies :

CEMT-9. Undertake projects related to energy management in production and service sectors, recognise and value advances and developments in the field and contribute innovative ideas.

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

### Full-or-part-time: 14h

Theory classes: 4h

Laboratory classes: 2h

Self study : 8h

## 3. Energy storage technologies

### Description:

Definition. History. Energy storage efficiency. Different ways to store energy. Energy storage techniques. PCM phase-change materials.

### Specific objectives:

It is intended to introduce students to the scientific and technical concepts related to the storage of thermal energy and its relationship to the efficient and rational use of energy.

### Related competencies :

CEMT-9. Undertake projects related to energy management in production and service sectors, recognise and value advances and developments in the field and contribute innovative ideas.

### Full-or-part-time: 10h

Theory classes: 4h

Self study : 6h

#### 4. Energy efficiency in buildings (housing sector)

**Description:**

Energy efficiency. Passive and active solar thermal systems.

**Specific objectives:**

It is intended to provide a solid information, though not exhaustive, on solar thermal energy and the possibility to harness it in buildings.

Once completed the module, students should be able to:

- To know the available solar energy on the surface of the earth and what is its potential use
- Know how the Sun's position is calculated based on the time of year, to maximize solar gains in buildings. These solar gains may be applied to both active systems (heating and water heating) and passive systems.
- Have a rough idea of what kind of systems are used for the utilization of solar energy in buildings.

**Related activities:**

2. Evaluation exercise #1

**Related competencies :**

CEMT-9. Undertake projects related to energy management in production and service sectors, recognise and value advances and developments in the field and contribute innovative ideas.

**Full-or-part-time:** 35h

Theory classes: 4h

Guided activities: 7h 30m

Self study : 23h 30m

#### 5. Energy efficiency in buildings (industry and services)

**Description:**

Implementation of energy audit methods. Energy efficiency in electrical systems.

- 1) Presentation of the most important technologies for energy efficiency in electrical systems
- 2) Quality of supply
- 3) Engines and Drives
- 4) Power Systems

Energy efficiency in lighting systems.

**Specific objectives:**

Provide students with the knowledge needed to evaluate the energy efficiency of electrical systems, through the description of the main characteristics of these systems and those of the electrical machines.

**Related competencies :**

CEMT-9. Undertake projects related to energy management in production and service sectors, recognise and value advances and developments in the field and contribute innovative ideas.

**Full-or-part-time:** 10h

Theory classes: 4h

Self study : 6h



## 6. Energy efficiency in industry

### Description:

Electricity and heat demand in industrial facilities. Cogeneration, efficiency parameters. Cogeneration technologies.

### Specific objectives:

On the one hand, it is intended to introduce students to the concept of thermoelectric cogeneration (CHP) and its use as a tool for improving energy management in industries, and their overall energy efficiency.

It is further intended to develop, through practical exercises and a lab session, student's skills in performing energy balances and calculating energy efficiency.

### Related activities:

3. Evaluation exercise #2
4. Free-cooling and heat re-utilization in the CTTC data center

### Related competencies :

CEMT-9. Undertake projects related to energy management in production and service sectors, recognise and value advances and developments in the field and contribute innovative ideas.

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

### Full-or-part-time: 40h

Theory classes: 4h

Laboratory classes: 2h

Guided activities: 7h 30m

Self study : 26h 30m

## 7. Energy efficiency in transportation

### Description:

Trains and trams. Other modes of transportation.

- 1) Basic Concepts
- 2) Railway installations
- 3) Criteria of efficiency in design and operation of railways
- 4) Technologies for Energy Efficiency
- 5) Other electric or hybrid vehicles

### Specific objectives:

Provide students with the knowledge needed to assess energy efficiency in railway transport, through the description of its main features and efficiency parameters. It is further intended to introduce students to electric and hybrid vehicles as alternative technologies to conventional vehicles to improve efficiency at local and at global scale.

### Related competencies :

CEMT-9. Undertake projects related to energy management in production and service sectors, recognise and value advances and developments in the field and contribute innovative ideas.

### Full-or-part-time: 10h

Theory classes: 4h

Self study : 6h

## ACTIVITIES

### 1. Refrigeration and air conditioning cycles and heat exchangers (HVAC & R). Heat pump water heater

**Description:**

The activity consists in carrying out the energy balances of a water heater with a heat pump and its components, including the heat storage tank.

**Specific objectives:**

- To deepen in the theoretical knowledge and its application to the experimental determination of parameters related to energy efficiency.
- To develop students' skills in carrying out energy balances from experimental data.

**Material:**

Data to perform the energy balances.

**Delivery:**

Result Report

**Related competencies :**

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

**Full-or-part-time:** 6h

Self study: 4h

Practical classes: 2h

### 2. Evaluation exercise #1

**Description:**

The activity consists of sizing a solar thermal system

**Specific objectives:**

- To deepen in the theoretical knowledge and its application to solving practical exercises about analysis and design.
- To develop students' skills in the selection and sizing of equipment for solar thermal systems as well as for the calculation of the performance of existing equipment and facilities.
- To deepen in the theoretical knowledge and its application to solving practical exercises about analysis and design.
- To develop students' skills in the selection and sizing of equipment for solar thermal systems as well as for the calculation of the performance of existing equipment and facilities.

**Material:**

Exercise statement

**Delivery:**

Result Report

**Related competencies :**

CEMT-9. Undertake projects related to energy management in production and service sectors, recognise and value advances and developments in the field and contribute innovative ideas.

**Full-or-part-time:** 15h

Self study: 7h 30m

Guided activities: 7h 30m

### 3. Evaluation exercise #2

**Description:**

The activity consists in carrying out the energy balances of different types of cogeneration plants, also in the analysis of their energy efficiency standards.

**Specific objectives:**

- To deepen in the theoretical knowledge and its application to solving practical exercises about analysis and design.
- To develop students' skills in performing energy balances in industrial plants, also on the analysis of energy efficiency parameters.

**Material:**

Exercise statement

**Delivery:**

Result Report

**Related competencies :**

CEMT-9. Undertake projects related to energy management in production and service sectors, recognise and value advances and developments in the field and contribute innovative ideas.

**Full-or-part-time:** 15h

Self study: 7h 30m

Guided activities: 7h 30m

### 4. Free-cooling and heat re-utilization in the CTTC data center

**Description:**

The activity consists in the analysis of energy savings through the free cooling system, as in the case of one who controls the temperature and humidity in the chamber of a data centre

**Specific objectives:**

- To deepen the theoretical knowledge and its application to the experimental determination of parameters related to energy efficiency.
- To develop students' skills in carrying out energy balances from experimental data.

**Material:**

Experimental setup

**Delivery:**

Result Report

**Related competencies :**

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

**Full-or-part-time:** 6h

Self study: 4h

Laboratory classes: 2h

## GRADING SYSTEM

Working group: 35%

Laboratory work: 15%

Exam final: 50%





## BIBLIOGRAPHY

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### Basic:

- Eastop, T. D.; Croft, D. R. Energy efficiency : for engineers and technologists. Harlow, Essex, England : New York: Longman Scientific & Technical ; Wiley, 1990. ISBN 9780582031845.
- Duffie, J. A.; Beckman, W. A. Solar engineering of thermal processes [on line]. 4th ed. Chichester: Wiley, 2013 [Consultation: 20/09/2022]. Available on: <https://onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/book/10.1002/9781118671603>. ISBN 9781118671603.
- Balcomb, J. Douglas. Passive solar design handbook. New York: American Solar Energy Society, cop. 1983-. ISBN 0895531240.
- González Fernández, Francisco Javier; Fuentes Losa, Julio. Ingeniería ferroviaria. 2a ed. act. y ampl. Madrid: Universidad Nacional de Educación a Distancia, 2010. ISBN 9788436260748.

### Complementary:

- SGS TECNOS, S.A.. Guia metodològica per a realitzar auditories energètiques [on line]. Barcelona: Generalitat de Catalunya, Institut Català d'Energia, 2011 [Consultation: 20/04/2023]. Available on: [https://icaen.gencat.cat/web/.content/10\\_ICAEN/17\\_publicacions\\_informes/08\\_quies\\_informes\\_estudis/informes\\_i\\_estudis/arxius/2011\\_guia\\_auditories\\_secured.pdf](https://icaen.gencat.cat/web/.content/10_ICAEN/17_publicacions_informes/08_quies_informes_estudis/informes_i_estudis/arxius/2011_guia_auditories_secured.pdf).
- Mitjà i Sarvisé, Albert. Atlas de radiació solar a Catalunya. Ed 2000. Barcelona: GC, Dpt. Indústria, Comerç i Turisme (Institut Català d'Energia), 2001.
- Energy efficiency in buildings. 2nd ed. London: CIBSE, cop. 2004. ISBN 9781903287347.
- Clark II, William H.; Míguez Gómez, Claudio. Análisis y gestión energética de edificios : métodos, proyectos y sistemas de ahorro energético. Madrid: McGraw-Hill, cop. 1998. ISBN 8448121023.
- Querol, E.; Gonzalez-Regueral, B.; Perez-Benedito, J. L. Practical approach to exergy and thermoeconomic analyses of industrial processes [on line]. 1st ed. London: Springer London, 2013 [Consultation: 19/09/2022]. Available on: <https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-1-4471-4622-3>. ISBN 9781283909181.
- American Society of Heating, Refrigerating and air-Conditioning Engineers. The ASHRAE handbook. Refrigeration.... IP and SI ed. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2008-. ISBN 9781936504732.

## RESOURCES

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### Hyperlink:

- World energy outlook. [www.iea.org/weo/](http://www.iea.org/weo/)