

## 820759 - CTEAB - Thermal Conditioning of Buildings. Bioclimatic Architecture

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering  
Teaching unit: 724 - MMT - Department of Heat Engines  
Academic year: 2019  
Degree: ERASMUS MUNDUS MASTER'S DEGREE IN ENVIRONMENTAL PATHWAYS FOR SUSTAINABLE ENERGY SYSTEMS (Syllabus 2012). (Teaching unit Optional)  
MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2013). (Teaching unit Optional)  
ERASMUS MUNDUS MASTER'S DEGREE IN ENVIRONMENTAL PATHWAYS FOR SUSTAINABLE ENERGY SYSTEMS (Syllabus 2013). (Teaching unit Optional)  
MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2013). (Teaching unit Optional)  
ECTS credits: 5 Teaching languages: English

### Teaching staff

Coordinator: Ivette Rodríguez  
Others: Ivette Rodríguez

### Opening hours

Timetable: Tuesday, Wednesday 16-18h; Thursday 16-18h

### Prior skills

Fundamental aspects of thermodynamics, fluid mechanics and heat transfer required to understand the thermal performance of buildings.

### Requirements

Those equivalent to have passed the Master leveling course.

### 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-5. Employ technical and economic criteria to select the most appropriate thermal equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technological applications in the production, transportation, distribution, storage and use of thermal 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.

## 820759 - CTEAB - Thermal Conditioning of Buildings. Bioclimatic Architecture

### Teaching methodology

During the development of the course the following teaching methods will be used:

- Lecture or conferences (EXP): Lectures taught by the professors of the course as well as invited lectures.
- Interactive classes (PART): resolution of exercises, collective discussions with both the teacher and the students. Presentation by the students of exercises carried out individually or in small groups.
- Oriented theoretical-practical works (TD): completion of a classroom activity, theoretical or practical, carried out individually or in small groups with the teacher's guidance.
- Project, activity or work of reduced scope (PR): Self-learning based on accomplishing an activity of reduced scope, individually or in small groups, just applying the knowledge acquired.
- Project or work of broader scope (PA): Self-learning based on accomplishing an activity of broader scope, individually or in small groups, just applying the knowledge acquired.
- Assessment exam (EV).

### Learning objectives of the subject

- Know the different heat transfer phenomena (radiation, convection, conduction) that occur in in the building.
- Know the different design criteria and basic concepts related to the thermal conditioning of buildings and the bioclimatic architecture.
- Know the regulations applicable to projects of bioclimatic buildings and thermal certification of buildings.
- Have a knowledge of the methodologies for calculating thermal loads in buildings: from simplified models to advanced numerical simulation techniques.
- Perform laboratory practices that allow the student to know the different phenomenologies present in buildings as well as the possibilities of numerical tools for the estimation of the building thermal loads.
- Know different techniques of air conditioning and heating using bioclimatic architecture criteria.

### Study load

Total learning time: 125h	Hours small group:	30h	24.00%
	Guided activities:	10h	8.00%
	Self study:	85h	68.00%

## 820759 - CTEAB - Thermal Conditioning of Buildings. Bioclimatic Architecture

### Content

<p>Introduction</p>	<p>Learning time: 7h Laboratory classes: 4h Self study : 3h</p>
<p>Description: Role of the engineer in the design of air conditioning and heating systems. Basics of heat transfer (conduction, convection, radiation). Basic thermodynamic processes in buildings, psicometical processes.</p> <p>Related activities: - Lectures or conferences - Interactive classes</p> <p>Specific objectives: - Know the tasks to be carried out by an engineer designing heating and air conditioning systems and how to integrate them in order to achieve an efficient design from an energy standpoint as well as from the point of view of comfort and safety. - Master the basic principles of heat transfer, as well as the air moist thermodynamic processes necessary to understand the different phenomenologies present in buildings.</p>	
<p>Air quality and thermal comfort</p>	<p>Learning time: 11h Laboratory classes: 3h Self study : 8h</p>
<p>Description: Comfort indexes, variables that influence thermal comfort, comfort assessment. Ventilation and indoor air quality. Sick building syndrome, evaluation of pollutants indexes. Efficacy of ventilation.</p> <p>Related activities: - Lectures or conferences - Interactive classes - Project, activity or work of reduced scope</p> <p>Specific objectives: - Understanding the thermal conditioning of buildings involves creating spaces with thermal comfort conditions. It aims to study how human responses are interrelated to the environment thermal conditions. - Know the different variables that can influence the thermal comfort and be able to assess the thermal comfort indices. - Know what sick building syndrome is, what their characteristics and symptoms are and what the risk factors are: chemical polluting, physical and biological in a sick building and psychosocial aspects.</p>	

## 820759 - CTEAB - Thermal Conditioning of Buildings. Bioclimatic Architecture

<p>Solar radiation and building. Boundary Conditions</p>	<p>Learning time: 19h Laboratory classes: 4h Self study : 15h</p>
<p>Description: Basic concepts of solar radiation. Estimation of solar radiation loads in buildings. Solar geometry and shade calculation. Other climatic variables: temperature and humidity. Influence of wind.</p> <p>Related activities: - Lectures or conferences - Interactive classes - Project, activity or work of reduced scope</p> <p>Specific objectives: - Be able to evaluate the angular position of the Sun - Be able to estimate the solar radiation thermal loads on the envelope of a building. - Evaluate the shadows that can occur on the facade of a building. - Determine all the boundary conditions necessary for a calculation of thermal loads in a building: solar radiation, temperature, humidity, wind speed.</p>	
<p>Heating and air conditioning thermal loads estimation</p>	<p>Learning time: 26h Laboratory classes: 6h Self study : 20h</p>
<p>Description: Estimation of thermal loads for both heating and cooling. Design conditions of indoor air. Heat transfer through the skin of the building. Air ventilation and infiltration. Internal heat gains (occupants, lighting, equipment, etc.). Other considerations.</p> <p>Related activities: - Lectures or conferences - Interactive classes - Project, activity or work of reduced scope</p> <p>Specific objectives: - Know the construction characteristics of the building, in order to determine the influence of the the building skin on the heat gains/losses and its temporal evolution. - Learn the different sources of heat losses and gains in a building that can influence the estimation of thermal loads for air conditioning and heating. - Estimate the impact of the different sources of heat losses and gains on the total demand for heating and cooling in a building. - Know the different methods for calculating thermal loads and the different tools available to an engineer in estimating the total demand for heating and cooling in a building.</p>	

## 820759 - CTEAB - Thermal Conditioning of Buildings. Bioclimatic Architecture

<p>Theoretical and practical considerations for thermal design. Energy efficiency in buildings</p>	<p>Learning time: 6h Laboratory classes: 2h Self study : 4h</p>
<p>Description: Regulations applicable to the thermal design of buildings. Technical building code (CTE) and thermal facilities regulations (RITE). Heat demand and the need to establish a maximum consumption. Energy efficiency in buildings and the introduction of renewable energy and the use of waste energy. Buildings with almost zero energy: principles and challenges. Smart-cities and heat pumps.</p> <p>Related activities: - Lectures or conferences</p> <p>Specific objectives: - Know the current regulations related to the thermal design of a building. - Understand the role of the Technical Building Code and the thermal demands imposed by it. - Know the current trends and the energy planning towards 2020 horizon in Europe. - Understand what a building with almost zero energy means, what the current state of the art is and what the main challenges to be faced are. - Know how to integrate different technologies to achieve buildings with almost zero energy. - What are smart-cities technologies and how heat pumps can be used.</p>	
<p>Techniques for passive cooling and heating of the building</p>	<p>Learning time: 40h Laboratory classes: 7h Guided activities: 6h Self study : 27h</p>
<p>Description: Study of different design techniques that consider all the climate impacts existing in a building: bioclimatic architecture. Techniques for passive cooling: evaporative cooling, radiation cooling, free cooling. Concepts and definitions. Types of facilities. Passive solar collection systems: direct gain systems, greenhouses, energy storage systems: Trombe wall, walls with phase change materials. Examples of application. Calculation and design of bioclimatic buildings.</p> <p>Related activities: - Lectures or conferences - Interactive classes - Oriented theoretical-practical works - Project, activity or work of broader scope</p> <p>Specific objectives: - Know the bioclimatic architecture concepts. - Recognize the different environmental elements that can be used in a bioclimatic project. - Enable the student in the different bioclimatic design techniques and their integration in the building in order to achieve current designs, efficient and targeted within 2020 horizon for buildings with almost zero energy. - Provide students with tools and knowledge for making decisions in the field of passive control of climatic variables.</p>	



## 820759 - CTEAB - Thermal Conditioning of Buildings. Bioclimatic Architecture

Advanced techniques for building thermal simulation

Learning time: 13h

Laboratory classes: 4h

Guided activities: 6h

Self study : 3h

**Description:**

The student should be able of using numerical techniques for simulating the thermal behaviour of a building. The different subjects treated throughout the course should be necessary to accomplish successfully this topic.

**Related activities:**

- Lectures or conferences
- Interactive classes
- Oriented theoretical-practical works

**Specific objectives:**

Use of the different concepts treated throughout the course to be applied in the simulation of a small building  
Learn different techniques and tools for building simulation

## 820759 - CTEAB - Thermal Conditioning of Buildings. Bioclimatic Architecture

### Planning of activities

Lectures and theoretical classes	Hours: 25h Self study: 10h Laboratory classes: 15h
<p><b>Description:</b> The content of the course is taught following an expository and participative model. The material is organized into different groups according to the content areas of knowledge of the subject.</p> <p><b>Support materials:</b> Recommended bibliography. Slides of the course</p> <p><b>Descriptions of the assignments due and their relation to the assessment:</b> This activity is evaluated in conjunction with activity 2 (problems) via assessment exercises and tests of knowledge.</p> <p><b>Specific objectives:</b> At the end of this activity, students should be able to master the knowledge, consolidate and apply them correctly to various technical problems. Moreover, being a subject techno applied the lectures should serve as a complement to other technical subjects related to the field heat as Refrigeration and Solar Heat Engines.</p>	
Participative classes	Hours: 25h Self study: 10h Laboratory classes: 15h
<p><b>Description:</b> During these activities, problems and exercises will be conducted using a participatory model class. On each topic, there will be some problems in class so that students can acquire the necessary methodology to carry out their resolution: simplifying assumptions, numerical resolution, discussion of the results.</p> <p><b>Support materials:</b> Basic and complementary bibliography. Teacher slides</p> <p><b>Descriptions of the assignments due and their relation to the assessment:</b> This activity is evaluated in conjunction with activity 1 (theory) via assessment exercises and tests of knowledge.</p> <p><b>Specific objectives:</b> At the end of this activity, students should be able to apply their theoretical knowledge to solve different kinds of problems. Given the methodology the student should be able to:</p> <ol style="list-style-type: none"> <li>1- Understand and analyze the problem statement.</li> <li>2 - Set up and develop a methodology for the resolution of the problem</li> <li>3 - Solve the problem with a suitable resolution algorithm.</li> <li>4. - Critically interpret the results.</li> </ol>	
Oriented theoretical-practical works	Hours: 22h Guided activities: 4h 30m Laboratory classes: 7h 30m Self study: 10h
<p><b>Description:</b> During these activities, laboratory activities for test equipment and systems studied in the course, as well as computer aided activities will be conducted.</p>	

## 820759 - CTEAB - Thermal Conditioning of Buildings. Bioclimatic Architecture

**Support materials:**

Notes and material provided by the professor via atenea

**Descriptions of the assignments due and their relation to the assessment:**

Report on the results obtained

**Specific objectives:**

Consolidate the knowledge acquired in theory and practice classes.

**Broader scope work**

Hours: 20h

Self study: 20h

**Description:**

The student will deepen into a subject and will solve a problem in which there must be necessary to apply different concepts acquired in the course. It is expected that the student is capable of using the different methodologies taught in class in order to accomplish the work.

**Support materials:**

Recommended bibliography. Teacher slides

**Descriptions of the assignments due and their relation to the assessment:**

Report on the results

**Specific objectives:**

Expand and consolidate the knowledge acquired in theory and practice classes.

**name english**

Hours: 30h

Self study: 30h

**Description:**

The student will carry out different theoretical or practical works throughout the course. These works can be whether the analysis of the current state-of-the-art in a certain subject or the evaluation of the thermal load through a building facade and/or in a small room.

**Support materials:**

Professor notes and recommended bibliography

**Descriptions of the assignments due and their relation to the assessment:**

Report on the results following the guidelines given by the professor

**Specific objectives:**

- Acquire basic knowledge about topics of interest to the course such as thermal comfort and building energy efficiency
- Being able to apply the knowledge acquired in both the theoretical as practical lessons to estimate the thermal loads on a facade of a building and / or estimate the heating and cooling loads of a building
- Being able to analyze the results and their dependence on the geographic location, the time of year, etc.. and propose solutions to improve energy efficiency from a thermal point of view

**Assessment tests**

Hours: 3h

Guided activities: 3h



## 820759 - CTEAB - Thermal Conditioning of Buildings. Bioclimatic Architecture

### Description:

Theoretical and practice exercises on the different subjects of the course will be assessed

### Specific objectives:

At the end of this activity, students should be able to demonstrate the knowledge acquired in the course, consolidate and apply the concepts correctly to various technical problems.

### Qualification system

- Final exam (PE): 50%
- Assessment exercises (individually or in small groups) (TR): 40%
- Attendance and participation in classes and laboratories (AP): 5%
- Quality and performance of the work in groups (TG): 5%

### Regulations for carrying out activities

- Final exam (PE): There will be a final exam for the course. Students must complete both theoretical questions and problems related to theoretical and practical content of the course. Reviews and / or complaints regarding exams will be conducted in accordance with the dates and times established in the academic calendar.
- Assessment exercises (TR): Students must follow the instructions explained in class and contained in the work file that will be proposed to the students. As a result of these activities, the student must submit a report (preferably in pdf format) to the teacher, within the deadline fixed for each activity. The assessment will involve both its realization as a possible defense.
- Attendance and participation in classes and laboratories (AP): Laboratory practices are assessed both during the development of the lab and by accomplishing a practical exercises proposed; The report resulting from the lab will be handed in to the professor following the instructions given in class. The assessment will involve both practical realization, as a possible defense.
- Quality and performance of group work (TG): Practices and class exercises will be assessed individually or in small groups by means of their oral defense if necessary.

## 820759 - CTEAB - Thermal Conditioning of Buildings. Bioclimatic Architecture

### Bibliography

#### Basic:

Cook, Jeffrey. Passive cooling. Cambridge: MIT Press, cop. 1989. ISBN 0262031477.

Balcomb, J. Douglas. Passive solar buildings. London: The MIT Press, cop. 1992. ISBN 0262023415.

Hays, Steve M; Gobbell, Ronald V; Ganick, Nicholas R. Indoor air quality : solutions and strategies. New York: McGraw-Hill, cop. 1995. ISBN 0070273731.

Kreider, Jan F. [et al.]. Heating and cooling of buildings : design for efficiency. 2n ed. rev.. Boca Raton: CRC Press, 2010. ISBN 9781439811511.

The ASHRAE handbook. I-P and SI ed. Atlanta, GA: American Society of Heating, Refrigerating and air-Conditioning Engineers, 2013-. ISBN 9781936504473.

#### Complementary:

Duffie, John A; Beckman, William A. Solar engineering of thermal processes. 3rd ed. Hoboken, N.J.: John Wiley & Sons, cop. 2006. ISBN 9780471698678.

Johnston, David; Gibson, Scott. Toward a zero energy home : a complete guide to energy self-sufficiency at home. Newtown: The Taunton Press, 2010. ISBN 9781600851438.

#### Others resources:

##### Audiovisual material

###### Transparències

Slides, problems proposed to be used in class

##### Computer material

###### Apunts

Notes made ??by the subject teacher