240EN31 - Biomass and Waste

**Coordinating unit:** 240 - ETSEIB - Barcelona School of Industrial Engineering

**Teaching unit:** 724 - MMT - Department of Heat Engines

**Academic year:** 2019

**Degree:** MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2013). (Teaching unit Optional)

**ECTS credits:** 5

**Teaching languages:** English

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### Teaching staff

**Coordinator:** Velo Garcia, Enrique

**Others:**
- Arranz Piera, Pol
- Valderrama Angel, Cesar Alberto
- Horta Sellares, Frederic

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### Opening hours

**Timetable:** To be published in the teaching intranet

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### Prior skills

- Stoichiometry of chemical reactions.
- Fundamentals of thermodynamics.
- Fundamentals of heat transfer.

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### Requirements

- Thermal equipment.

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### Degree competences to which the subject contributes

**Specific:**

- **CEEN1. (ENG)** Entendre, descriure i analitzar, de forma clara i àmplia tota la cadena de conversió energètica, des del seu estat com "font d'energia" fins el seu us com "servei energètic". Identificar, descriure i analitzar la situació i característiques dels diferents recursos energètics i dels usos finals de l'energia, en les seves dimensions econòmica, social i ambiental; i formular judicis valoratius.

- **CEEN4. (ENG)** Realitzar de manera eficient l'obtenció de dades de recursos renovables d'energia i el seu tractament estadístic, així com aplicar coneixements i criteris de valoració en el diseny i avaluació de solucions tecnològiques per a l'aprofitament de recursos renovables d'energia, tant per a sistemes aïllats com connectats a xarxa. Reconéixer i valorar les aplicacions tecnològiques més novedoses dels recursos renovables d'energia.

- **CEEN5. (ENG)** Aplicar criteris tècnics i econòmics en la selecció de l'equip tèrmic més adequat per a una determinada aplicació. Dimensionar equips e instal·lacions tèrmiques. Reconéixer i valorar les aplicacions tecnològiques més novedoses en l’àmbit de la producció, transport, distribució, emmagatzematge i us de l'energia.

- **CEEN7. (ENG)** Analitzar el comportament d'equips e instal·lacions en operació a fi d'elaborar un diagnòstic valoratiu sobre el seu règim d'explotació i d'establir mitjans dirigits a millorar la seva eficiència energètica.
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Teaching methodology

The course teaching methodologies are as follows:

- 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.

Training activities:

The course training activities are as follows:

Face to face activities
- Lectures and conferences: learning based on understanding and synthesizing the knowledge presented by the teacher or by invited speakers.
- Participatory sessions: learning based on participating 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): learning based on presenting in the classroom an activity individually or in small groups.
- Theoretical/practical supervised work (TD): learning based on performing an activity in the classroom, or a theoretical or practical exercise, individually or in small groups, with the advice of the teacher.

Study activities
- Homework assignment of reduced extension (PR): learning based on applying knowledge and presenting results.
- Homework assignment of broad extension (PA): learning based on applying and extending knowledge.
- Self-study (EA): learning based on studying or expanding the contents of the learning material, individually or in groups, understanding, assimilating, analysing and synthesizing knowledge.

Learning objectives of the subject

The course focuses on technologies using biomass and waste as energy resource. In this area it is intended that students acquire the knowledge and skills necessary for describing and selecting equipment, as well as for calculating the performance of existing equipment and facilities, at a basic level. It is intended to provide an overview of the technologies and methods that will enable the student to make judgments, and studies of alternatives in the context of engineering projects.

Learning Outcomes

At the end of the course, the student:
- Is able to describe the role of biomass in the context of the energy system at the global and regional scale, its economic, social and environmental connotations, and the impact of technologies on a local and global context and is able to develop value judgments about the opportunities, threats and barriers on biomass utilization.
- Is able to list the relevant organizations, major projects at the international level, the main sources of information and regulations related to biomass technologies.
- Is able to carry out a basic engineering project related to energy supply using biomass technologies.
- Is able to propose a pre-feasibility study, related to the use of biomass-to-energy systems in different industrial and service sectors.
- Is able to describe the main lines of research in the field of biomass technologies and waste and is able to bring innovative ideas.

### Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours medium group: 30h</th>
<th>24.00%</th>
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</thead>
<tbody>
<tr>
<td>Guided activities:</td>
<td>15h</td>
<td>12.00%</td>
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<tr>
<td>Self study:</td>
<td>80h</td>
<td>64.00%</td>
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</table>
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### Content

<table>
<thead>
<tr>
<th><strong>1. Biomass as energy resource</strong></th>
<th><strong>Learning time:</strong> 7h 20m</th>
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</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td></td>
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<tr>
<td>Definition of biomass.</td>
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<tr>
<td>Nature and types of biomass</td>
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<tr>
<td>according to their composition.</td>
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<tr>
<td>Sources of biomass.</td>
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<tr>
<td>Biomass utilization for energy</td>
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<tr>
<td>purposes.</td>
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<tr>
<td>Biomass utilization at local and</td>
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<tr>
<td>global scale.</td>
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<tr>
<td>Regional and National policies</td>
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<tr>
<td>promoting biomass utilization.</td>
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</table>

**Related activities:**
Quiz about biomass as energy resource
Project

**Specific objectives:**
- The student understands the role of biomass as a renewable source of energy in production and service sectors, as well as its importance in the energy chain: processing, transportation, distribution and end-use of energy; and is able to develop value judgments about the opportunities, threats and barriers on biomass utilization.
- The student knows and understands the relevant organizations, major projects at the international level, the main sources of information and regulations related to biomass technologies.

<table>
<thead>
<tr>
<th><strong>2. Characterization and properties</strong></th>
<th><strong>Learning time:</strong> 9h 10m</th>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td></td>
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<tr>
<td>Characteristics of biomass as a fuel</td>
<td></td>
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<tr>
<td>- Solids, liquids and gases</td>
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<tr>
<td>- Types of analysis</td>
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<tr>
<td>- Heating value</td>
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</tbody>
</table>

**Related activities:**
Exercise on characterization and properties of biofuels.
Project.

**Specific objectives:**
- The student knows and understands the main characteristics of biofuels and methods for determining their properties.
- The student has the knowledge and skills necessary for the determination of the energy characteristics of biofuels.
## 3. Energy crops & forestry biomass

### Description:
- Characteristics.
- Types of crops.
- Forest crops.
- Agricultural species.
- Strategic Projects.
- Policies for their development, and future prospects of energy crops.

### Related activities:
- Exercise about forest biomass supply
- Project

### Specific objectives:
- The student understands the role of energy crops in the context of the energy system at the global and regional scale, their economic, social and environmental connotations, and the impact of technologies on a local and global context and is able to develop value judgments about the opportunities, threats and barriers on their utilization.
- The student knows the main lines of research in the field of energy crops.

### Learning time:
- Theory classes: 0h 50m
- Practical classes: 2h 15m
- Guided activities: 0h 20m
- Self study: 3h

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## 4. Supply chain

### Description:
- Theory of supply chain, strategic planning and its components.
- Stages of the chain, example of sustainability indicators.
- Configurations: technologies & efficiencies.
- Comparisons between configurations markets.
- Leading companies.

### Related activities:
- Exercise on designing and planning a supply chain
- Project

### Specific objectives:
- The student understands the components of a biomass supply chain and their main characteristics.
- The student is able to make a preliminary design and analysis of a supply chain

### Learning time:
- Practical classes: 3h
- Self study: 7h
### 5. The combustion process with electricity and heat production

**Description:**
Fundamentals of combustion.
Heat and power using combustion technologies.
- Burners and combustion equipment.
- Heating and DHW
- Power generation.
- Other applications
- Thermochemical Basis
- Energy analysis.

**Related activities:**
Exercises on biomass combustion with electric and thermal energy production.
Project.

**Specific objectives:**
- The student is able to prepare a pre-feasibility study, related to the use of biomass combustion systems in different industrial and service sectors, by assessing the available resources.
- The student is able to carry out a basic engineering project related to energy supply using biomass combustion technologies.

**Learning time:** 11h
- Theory classes: 2h 30m
- Practical classes: 1h
- Guided activities: 3h 30m
- Self study: 4h

### 6. Pyrolysis and gasification processes

**Description:**
Introduction
Opportunities and Future Prospects
Thermochemical principles
Classification of technologies
Electricity production by gasification
Pyrolysis processes

**Related activities:**
Project

**Specific objectives:**
- The student is able to prepare a pre-feasibility study, related to the use of biomass gasification systems in different industrial and service sectors, by assessing the available resources.
- The student is able to carry out a basic engineering project related to energy supply using biomass gasification technologies.

**Learning time:** 7h
- Theory classes: 1h
- Practical classes: 1h
- Guided activities: 1h
- Self study: 4h
## 7. Waste to energy

**Learning time:** 3h  
Self study : 3h

### Description:
- Environmental impacts of waste to energy (WTE) conversion plants
- Types of feedstock for WTE systems and their characteristics
- Waste to energy systems, engineering and technology
- Pollution control systems for waste to energy technologies
- WTE conversion plants in the framework of Circular Economy Policy

### Related activities:
- Project

### Specific objectives:
- The student is able to analyse and estimate the potential energy recovery from feedstock and the significant benefits that represent their valorisation in waste-to-energy systems.
- The student is able to evaluate a waste-to-energy conversion plant from a sustainable perspective.

## 8. Legislation and regulatory frameworks

**Learning time:** 5h  
Guided activities: 1h  
Self study : 4h

### Description:
- European regulations.
- Spanish legislation.

### Related activities:
- Project

### Specific objectives:
- The student knows and understands the environmental connotations of the use of biomass and waste as energy sources and be able to make value judgments.
- The student knows the main regulatory frameworks for the use of biomass and waste as energy sources.
9. Socioeconomic aspects

<table>
<thead>
<tr>
<th>Learning time: 6h</th>
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<tbody>
<tr>
<td>Practical classes: 2h</td>
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<tr>
<td>Self study: 4h</td>
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</tbody>
</table>

**Description:**
Social and economic impact.
Value Chain
Business Case Studies

**Related activities:**
Project

**Specific objectives:**
- The student knows and understands the role of biomass in the context of the energy system at the global and regional scale, its economic, social and environmental connotations, and the impact of technologies on a local and global context and is able to develop value judgments about the opportunities, threats and barriers on biomass utilization.
- The student knows the policies of promotion of biomass as an energy resource and is able to critically analyse them.

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**Project**

<table>
<thead>
<tr>
<th>Learning time: 60h 05m</th>
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<tbody>
<tr>
<td>Theory classes: 3h 40m</td>
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<tr>
<td>Practical classes: 7h 50m</td>
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<tr>
<td>Guided activities: 7h 35m</td>
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<tr>
<td>Self study: 41h</td>
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</tbody>
</table>

**Description:**
Project about energy supply using solid biomass as energy resource.
The aim of this project is to complete a feasibility study and a preliminary design of a biomass fuelled energy supply system in a county of Catalonia.

**Related activities:**
Study visit
Project

**Specific objectives:**
The student is able to carry out a feasibility study for the supply of energy services using biomass as energy resource, including the design of the supply chain and the pre-design of the main components of the energy system.

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**Qualification system**

35% Written tests for the evaluation of acquired knowledge (PE)
15% Attendance and participation (AP)
50% Homework (TR)
Regulations for carrying out activities

The specific rules for written tests and for individual and group work will be published on the teaching intranet.

Bibliography

Complementary:


Others resources:


World Energy Outlook http://www.worldenergyoutlook.org/