820746 - BMR - Biomass and Waste

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering
Teaching unit: 724 - MMT - Department of Heat Engines
Academic year: 2018
Degree: ECTS credits: 2,5

Teaching languages: English

Coordinator: Velo Garcia, Enrique
Others: César Alberto Valderrama
Frederic Horta Sellarés
Pol Arranz Piera

Opening hours
Timetable: To be published in the teaching intranet

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

Requirements
- Thermal equipment.

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.
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: 62h 30m</th>
<th>Hours large group:</th>
<th>0h</th>
<th>0.00%</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>15h</td>
<td>24.00%</td>
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<tr>
<td></td>
<td>Hours small group:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Guided activities:</td>
<td>5h</td>
<td>8.00%</td>
</tr>
<tr>
<td></td>
<td>Self study:</td>
<td>42h 30m</td>
<td>68.00%</td>
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</tbody>
</table>
## Content

### 1. Biomass as energy resource

**Description:**
- Definition of biomass.
- Nature and types of biomass according to their composition.
- Sources of biomass.
- Biomass utilization for energy purposes.
- Biomass utilization at local and global scale.
- Regional and National policies promoting biomass utilization.

**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.

**Learning time:** 6h
- Theory classes: 3h
- Self study: 3h

### 2. Characterization and properties.

**Description:**
- Characteristics of biomass as a fuel
- Solids, liquids and gases
- Types of analysis
- Heating value

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

**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.

**Learning time:** 3h 30m
- Theory classes: 0h 30m
- Self study: 3h
### 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.

**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.

### 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:**
2. Exercise on designing and planning a supply chain

**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
## 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:**
- 3. Exercises on biomass combustion with electric and thermal energy production.

**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:
- **Theory classes:** 2h
- **Self study:** 18h

## 6. Pyrolysis and gasification processes

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

**Related activities:**
- 4. Exercises about power generation by biomass gasification.

**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:
- **Theory classes:** 2h
- **Self study:** 12h
### 7. Waste to energy

**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:**
- Exercises devoted to estimate: the calorific value of waste-feedstock; the energy production and the emissions generated in waste-to-energy facilities.

**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.

<table>
<thead>
<tr>
<th>Learning time: 7h</th>
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<tbody>
<tr>
<td>Theory classes: 2h</td>
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<tr>
<td>Self study : 5h</td>
</tr>
</tbody>
</table>

### 8. Legislation and regulatory frameworks

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

**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.

<table>
<thead>
<tr>
<th>Learning time: 3h</th>
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<tbody>
<tr>
<td>Theory classes: 1h</td>
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<tr>
<td>Self study : 2h</td>
</tr>
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</table>
### 9. Socioeconomic aspects

<table>
<thead>
<tr>
<th>Description:</th>
<th>Learning time: 9h</th>
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</thead>
<tbody>
<tr>
<td>Social and economic impact.</td>
<td>Theory classes: 1h</td>
</tr>
<tr>
<td>Value Chain</td>
<td>Practical classes: 2h</td>
</tr>
<tr>
<td>Business Case Studies</td>
<td>Self study: 6h</td>
</tr>
</tbody>
</table>

**Related activities:**
5. Study visit

**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.
## Planning of activities

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Hours:</th>
<th>Description:</th>
<th>Support materials:</th>
<th>Descriptions of the assignments due and their relation to the assessment:</th>
<th>Specific objectives:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Exercises on characterization and properties of biofuels.</strong></td>
<td>4h 30m</td>
<td>Autonomous resolution of exercises about characterization and properties of biofuels</td>
<td>Exercise statement, Bibliographic references and data sources.</td>
<td>Results report</td>
<td>To deepen in the theoretical knowledge and its application to solve practical exercises on characterization and properties of biofuels.</td>
</tr>
<tr>
<td><strong>2. Exercise on designing and planning a supply chain</strong></td>
<td>11h</td>
<td>Group work on an exercise about designing and planning a supply chain (role game)</td>
<td>Exercise statement, Bibliographic references and data sources.</td>
<td>Results report</td>
<td>To deepen in the theoretical knowledge and its application to solve practical exercises on supply chains design and planning.</td>
</tr>
<tr>
<td><strong>3. Exercises on biomass combustion with electric and thermal energy production.</strong></td>
<td>13h</td>
<td>Autonomous resolution of an exercise about biomass combustion with electric and thermal energy production.</td>
<td>Exercise statement, Bibliographic references and data sources, Solved examples.</td>
<td>Results report</td>
<td></td>
</tr>
</tbody>
</table>
### Descriptions of the assignments due and their relation to the assessment:

**Results report**

### Specific objectives:

To deepen in the theoretical knowledge and its application to solve practical exercises on biomass combustion.

### 4. Exercises about power generation by biomass gasification.

<table>
<thead>
<tr>
<th>Hours: 11h</th>
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</thead>
<tbody>
<tr>
<td>Laboratory classes: 2h</td>
</tr>
<tr>
<td>Guided activities: 4h</td>
</tr>
<tr>
<td>Self study: 5h</td>
</tr>
</tbody>
</table>

**Description:**

Autonomous resolution of an exercise about power generation by biomass gasification.

**Support materials:**

Exercise statement
Bibliographic references and data sources.
Solved examples

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

**Results report**

**Specific objectives:**

To deepen in the theoretical knowledge and its application to solve practical exercises on biomass gasification.

### 5. Study visit

<table>
<thead>
<tr>
<th>Hours: 2h</th>
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<tbody>
<tr>
<td>Laboratory classes: 2h</td>
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**Description:**

Visit to a biomass related business activity

**Specific objectives:**

To deepen in the knowledge of biomass related business models.

### Exam

<table>
<thead>
<tr>
<th>Hours: 2h</th>
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<tbody>
<tr>
<td>Theory classes: 2h</td>
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</tbody>
</table>

**Description:**

Written exam

**Specific objectives:**

Assess the student attainment on the course learning outcomes, as a complement of the practical work done by the student during the semester.
Qualification system

35% Exam (PE)
15% Attendance and participation (AP)
50% Homework (TR)

Regulations for carrying out activities

For the exam, the student may have only one sheet of paper with formulas and a programmable calculator. The specific rules of individual and group work will be published in the teaching intranet.

Bibliography

Complementary:


Others resources:


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