

Course guide

240EN31 - 240EN31 - Biomass and Waste

Last modified: 24/05/2023

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

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: 2023 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Velo Garcia, Enrique

Others:

PRIOR SKILLS

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

REQUIREMENTS

- Thermal equipment.

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 disseny i avaluació de solucions tecnològiques per a l'aprofitament de recursos renovables d'energia, tant per a sistemes aïllats com connectats a xarxa. Reconèixer 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. Reconèixer 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 i 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.

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.

In accordance with the recommendations and regulations published by UPC in relation to the resumption of activities during the health emergency caused by COVID19, the teaching will be carried out through online activities, synchronous and asynchronous, on the 'ATENA campus.

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

Type	Hours	Percentage
Hours medium group	30,0	24.00
Self study	80,0	64.00
Guided activities	15,0	12.00

Total learning time: 125 h

CONTENTS

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.

Related activities:

Quiz about biomass as energy resource
Project

Related competencies :

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.

Full-or-part-time: 7h 20m

Theory classes: 3h

Practical classes: 0h 30m

Guided activities: 0h 50m

Self study : 3h

2. Characterization and properties

Description:

Characteristics of biomass as a fuel

- Solids, liquids and gases
- Types of analysis
- Heating value

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.

Related activities:

Exercise on characterization and properties of biofuels.

Project.

Related competencies :

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. Reconèixer i valorar les aplicacions tecnològiques més novadores dels recursos renovables d'energia.

Full-or-part-time: 9h 10m

Theory classes: 0h 55m

Practical classes: 0h 30m

Guided activities: 0h 45m

Self study : 7h

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.

Related activities:

Exercise about forest biomass supply
Project

Related competencies :

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. Reconèixer i valorar les aplicacions tecnològiques més novadores dels recursos renovables d'energia.

Full-or-part-time: 6h 25m

Theory classes: 0h 50m

Practical classes: 2h 15m

Guided activities: 0h 20m

Self study : 3h

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.

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

Related activities:

Exercise on designing and planning a supply chain

Project

Related competencies :

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. Reconèixer i valorar les aplicacions tecnològiques més novadores en l'àmbit de la producció, transport, distribució, emmagatzematge i ús de l'energia.

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 al seu ús 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.

Full-or-part-time: 10h

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.

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.

Related activities:

Exercises on biomass combustion with electric and thermal energy production.

Project.

Related competencies :

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. Reconèixer i valorar les aplicacions tecnològiques més novadores en l'àmbit de la producció, transport, distribució, emmagatzematge i ús de l'energia.

CEEN7. (ENG) Analitzar el comportament d'equips i 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.

Full-or-part-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

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.

Related activities:

Project

Related competencies :

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. Reconeixer i valorar les aplicacions tecnològiques més novadores en l'àmbit de la producció, transport, distribució, emmagatzematge i us de l'energia.

CEEN7. (ENG) Analitzar el comportament d'equips i 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.

Full-or-part-time: 7h

Theory classes: 1h
Practical classes: 1h
Guided activities: 1h
Self study : 4h

7. 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.

Related activities:

Project

Related competencies :

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.

Full-or-part-time: 5h

Guided activities: 1h
Self study : 4h

8. Socioeconomic aspects

Description:

Social and economic impact.
Value Chain
Business Case Studies

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.

Related activities:

Project

Related competencies :

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.

Full-or-part-time: 6h

Practical classes: 2h

Self study : 4h

Project

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.

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.

Related activities:

Study visit
Project

Due to the health emergency caused by COVID 19, the field visit will be made in a reduced format or it will be canceled according to the possibilities and restrictions of the moment.

Related competencies :

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. Reconèixer i valorar les aplicacions tecnològiques més novadores en l'àmbit de la producció, transport, distribució, emmagatzematge i us de l'energia.

CEEN7. (ENG) Analitzar el comportament d'equips i 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.

Full-or-part-time: 60h 05m

Theory classes: 3h 40m

Practical classes: 7h 50m

Guided activities: 7h 35m

Self study : 41h

GRADING SYSTEM

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

EXAMINATION RULES.

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

BIBLIOGRAPHY

Complementary:

- Ministerio de Industria, Turismo y Comercio. Biomasa : cultivos energéticos [on line]. Madrid: IDAE, 2007 [Consultation: 05/04/2023]. Available on: https://www.idae.es/sites/default/files/documentos/publicaciones_idae/documentos_10737_biomasa_cultivos_energeticos_07_4bd9c8e7.pdf. ISBN 9788496680173.
- Hildegard Lyko, Görges Deerberg, Eckhard Weidner. "Coupled production in biorefineries - Combined use of biomass as a source of energy, fuels and materials". Journal of Biotechnology [on line]. 142 (2009) 78-86 [Consultation: 08/09/2016]. Available on: <http://www.sciencedirect.com/science/journal/01681656>.
- Larson, Eric D. Sustainable bioenergy : a framework for decision makers [on line]. New York: UN-Energy, 2007 [Consultation: 17/11/2022]. Available on: http://repositorio.cepal.org/bitstream/handle/11362/2856/1/UNEnergybioenergy_english_en.pdf.
- Van Loo, Sjaak ; Koppejan, Jaap. The handbook of biomass combustion and co-firing. London: Earthscan, cop. 2008. ISBN 9781844072491.
- Knoef, Harrie [ed.]. Handbook biomass gasification. 2nd ed. Enschede, the Netherlands: BTG Biomass Technology Group, 2012. ISBN 9789081938501.
- McGowan, T. F. [ed.]. Biomass and alternate fuel systems : an engineering and economic guide [on line]. Hoboken, NJ: John Wiley & Sons, cop. 2009 [Consultation: 19/09/2022]. Available on: <https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pg-origsite=primo&docID=588921>. ISBN 9780470410288.

RESOURCES

Other resources:

International Energy Agency. Technology Roadmap: Bioenergy for Heat and Power. Release Date: 29 May 2012
http://www.iea.org/publications/freepublications/publication/2012_Bioenergy_Roadmap_2nd_Edition_WEB.pdf />
The European Technology Platform on Renewable Heating and Cooling (RHC-Platform). Biomass Technology Roadmap. Brussels, 2014
http://www.rhc-platform.org/fileadmin/Publications/Biomass_Technology_Roadmap.pdf />
World Energy Outlook
<http://www.worldenergyoutlook.org/> />
REN21 RENEWABLES 2015. GLOBAL STATUS REPORT. Paris, 2015
http://www.ren21.net/wp-content/uploads/2015/07/REN12-GSR2015_Onlinebook_low1.pdf />