Course guide
820733 - AER - Renewable Energy Technology

Last modified: 08/07/2024

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering.

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

Coordinating lecturer: JOSE BORDONAU FARRERONS

Others: JOSE BORDONAU FARRERONS
Aragüés Peñalba, Mònica
Presas Batlló, Alexandre
Capdevila Paramio, Roser
Husar, Attila Peter
Cerrillo Moreno, Míriam

PRIOR SKILLS

- Fundamentals of applied physics
- Fundamentals of economy
- Economic analysis of projects

REQUIREMENTS

Welcomed to have knowledge on basic concepts of Thermodynamics (1st principle, energy balances) and Circuit Theory (ac single phase and three phase systems, dc systems).

TEACHING METHODOLOGY

Teaching methodology

The course teaching methodologies are as follows:

- Lectures and conferences: presentation of knowledge 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 (TD): 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: design, planning and implementation of a project or homework of broad extension by a group of students, and writing a report that should include the approach, results and conclusions.
- Evaluation activities (EV): i) an exam of each part of the course; ii) project of a hybrid energy system, usign different technologies with the program HOMER; iii) short assignments for each one of the sessions, with a component on innovation.

- Face to face activities:
o Lectures and conferences: learning based on understanding and synthesizing the knowledge presented by the teacher or by invited speakers.
o 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.
o Presentations (PS): learning based on presenting in the classroom an activity individually or in small groups.
o 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
o Homework assignment of reduced extension (PR): learning based on applying knowledge and presenting results.
o Homework assignment of broad extension (PA): learning based on applying and extending knowledge.
o 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

Objectives
The scope of the course corresponds to technologies for harnessing renewable energy. In this area it is intended that students acquire the knowledge and skills necessary for the description, selection and sizing, as well as for calculating the performance of equipment and pre-existing installations at a basic level or pre-project. The subject aims to give an overview of the technologies and methods that allow the student to perform assessments and studies of alternatives in engineering projects. Also, the course should serve as an introduction for students who follow the specialty of renewable energy which will deepen the study of the different technologies in optional courses.
Learning outcomes
Upon completing the course, the student should:
- Understand the role of renewable energy in product and service sectors, as well as its importance in the energy chain: processing, transportation, distribution and end use; understand energy efficiency and be capable of developing valuable judgments about opportunities, threats and barriers to their use.
- Know and understand the characteristics and key players in the renewable energies sector in Spain and Europe, as well as its importance in a productive economic context.
- Know and be able to critically analyse policies to promote renewable energy.
- Have the knowledge, skills and elements of analysis and judgment necessary to select the most appropriate systems from an energetic standpoint for different types of applications (industrial or service) as well as the ability to analyse the behaviour of a system in operation and make a diagnosis on the operating system.
- Have the knowledge, skills and elements of analysis and judgment necessary to consider a pre-feasibility study, related to the use of renewable energy systems in different industrial sectors and services.
- Know the main lines of research in the field of technologies for harnessing renewable energy.

STUDY LOAD

Type	Hours	Percentage
Hours small group	15,0	12.00
Hours large group	30,0	24.00
Self study	80,0	64.00

Total learning time: 125 h

CONTENTS

Table of contents

Description:
- Introduction to wind energy.
- Wind energy and interaction with the electrical grid.
- Introduction to solar thermal energy. Solar thermal energy utilisation systems.
- Introduction to solar photovoltaic energy. Solar photovoltaic energy utilisation systems.
- Hydraulic and marine energy.
- Fuel cells and fuel cell-based systems.
- Biogas and biofuels.
- Introduction to geothermal energy.

Specific objectives:
- The student has the knowledge, skills and elements of analysis and judgment necessary to consider a pre-feasibility study, related to the use of solar energy in different industrial sectors and services for the assessment of available resources.

Related activities:
- Analysis or synthesis based on innovations identified by students in each technology of the subject.
- Proposal of a hybrid renewable system based on the technologies covered in the subject and quantified with the HOMER programme.
- Participation in a roundtable discussion with experts.

Full-or-part-time: 8h 20m
Theory classes: 2h
Practical classes: 1h
Guided activities: 1h
Self study : 4h 20m

The renewables sector

Description:
- The renewables sector in Spain and Europe.
- Policies, plans and regulatory frameworks to promote.

Specific objectives:
- To know and understand the characteristics and key players in the sector of renewable energies in Spain and Europe, as well as its importance in a productive economic context.
- To know and be able to critically analyse policies to promote renewable energy.

Related activities:
2. Exercise on the renewables sector

Full-or-part-time: 8h 20m
Theory classes: 2h
Practical classes: 1h
Guided activities: 1h
Self study : 4h 20m

Solar thermal energy

Description:
- Solar thermal collectors for low, medium and high temperature (solar receivers).
- Thermal systems of medium and high temperature.
- Applications.

Specific objectives:
- The student has the knowledge, skills and elements of analysis and judgment necessary to select the most appropriate systems from an energetic standpoint for different types of applications (industrial or service) as well as the ability to analyse the behaviour of a system in operation and make a diagnosis on the operating system.
- The student has the knowledge, skills and elements of analysis and judgment necessary to consider a pre-feasibility study, related to the use of solar thermal systems in different industrial sectors and services.

Related activities:
4. Exercise on solar thermal energy

Full-or-part-time: 8h 20m
Theory classes: 2h
Practical classes: 1h
Guided activities: 1h
Self study : 4h 20m

Solar photovoltaic energy

Description:
- Photovoltaic generator.
- Other components of a photovoltaic installation.
- Isolated photovoltaic installations.
- Installations connected to the network.

Specific objectives:
- The student has the knowledge, skills and elements of analysis and judgment necessary to select the most appropriate systems from an energetic standpoint for different types of applications (industrial or service) as well as the ability to analyse the behaviour of a system in operation and make a diagnosis on the operating system.
- The student has the knowledge, skills and elements of analysis and judgment necessary to consider a pre-feasibility study, related to the use of solar PV systems in different industrial sectors and services.

Related activities:
5. Exercise on solar photovoltaic energy

Full-or-part-time: 8h 20m
Theory classes: 2h
Practical classes: 1h
Guided activities: 1h
Self study : 4h 20m

Wind energy

Description:
- Features of wind.
- Measure and calculate the energy available.
- Turbines.

Specific objectives:
- The student has the knowledge, skills and elements of analysis and judgment necessary to select the most appropriate systems from an energetic standpoint for different types of applications (industrial or service) as well as the ability to analyse the behaviour of a system in operation and make a diagnosis on the operating system.
- The student has the knowledge, skills and elements of analysis and judgment necessary to consider a pre-feasibility study, related to the use of wind power systems in different industrial sectors and services.

Related activities:
6. Exercise on wind energy

Full-or-part-time: 8h 20m
Theory classes: 2h
Practical classes: 1h
Guided activities: 1h
Self study : 4h 20m

Hydropower and ocean energy

Description:
- Central hydropower.
- Ocean energies: tidal energy, energy flows, ocean thermal energy, osmotic power or blue energy, wave energy.

Specific objectives:
- The student has the knowledge, skills and elements of analysis and judgment necessary to select the most appropriate systems from an energetic standpoint for different types of applications (industrial or service) as well as the ability to analyse the behaviour of a system in operation and make a diagnosis on the operating system.
- The student has the knowledge, skills and elements of analysis and judgment necessary to consider a pre-feasibility study, related to the use of hydropower and marine systems in different industrial sectors and services.

Related activities:
7. Exercise on hydropower and ocean energy

Full-or-part-time: 8h 20m
Theory classes: 2h
Practical classes: 1h
Guided activities: 1h
Self study : 4h 20m

Geothermal energy

Description:
- Assessment of available resources.
- Geothermal systems.

Specific objectives:
- The student has the knowledge, skills and elements of analysis and judgment necessary to select the most appropriate systems from an energetic standpoint for different types of applications (industrial or service) as well as the ability to analyse the behaviour of a system in operation and make a diagnosis on the operating system.
- The student has the knowledge, skills and elements of analysis and judgment necessary to consider a pre-feasibility study, related to the utilization of geothermal energy systems in different industrial sectors and services.

Related activities:
8. Exercise on geothermal energy

Full-or-part-time: 8h 20m
Theory classes: 2h
Practical classes: 1h
Guided activities: 1h
Self study : 4h 20m

Biomass and waste

Description:
- Biomass as an energy source.
- Sources of biomass.
- Production of heat and electricity.

Specific objectives:
- The student has the knowledge, skills and elements of analysis and judgment necessary to select the most appropriate systems from an energetic standpoint for different types of applications (industrial or service) as well as the ability to analyse the behaviour of a system in operation and make a diagnosis on the operating system.
- The student has the knowledge, skills and elements of analysis and judgment necessary to consider a pre-feasibility study, related to the use of biomass and waste systems in different industrial sectors and services.

Related activities:
9. Exercise on biomass and waste

Full-or-part-time: 8h 20m
Theory classes: 2h
Practical classes: 1h
Guided activities: 1h
Self study : 4h 20m

Biogas and biofuels

Description:
- Biofuels.
- Biofuels (biodiesel, bioethanol).
- Biogas.
- Biorefineries.

Specific objectives:
- The student has the knowledge, skills and elements of analysis and judgment necessary to select the most appropriate systems from an energetic standpoint for different types of applications (industrial or service) as well as the ability to analyse the behaviour of a system in operation and make a diagnosis on the operating system.
- The student has the knowledge, skills and elements of analysis and judgment necessary to consider a pre-feasibility study, related to the use of biogas and biofuels in different industrial sectors and services.

Related activities:
10. Exercise on biogas

Full-or-part-time: 8h 20m
Theory classes: 2h
Practical classes: 1h
Guided activities: 1h
Self study : 4h 20m

Hydrogen and fuel cells

Description:
- Hydrogen production technologies.
- Storage and transport of hydrogen.
- Fuel cells.

Specific objectives:
The student has the knowledge, skills and elements of analysis and judgment necessary to consider a pre-feasibility study, related to the use of hydrogen and fuel cells in different industrial sectors and services.

Related activities:
11. Exercise on hydrogen and fuel cells

Full-or-part-time: 8h 20m
Theory classes: 2h
Practical classes: 1h
Guided activities: 1h
Self study : 4h 20m

Hybrid systems

Description:
- Description.
- Calculation software.

Specific objectives:
- The student has the knowledge, skills and elements of analysis and judgment necessary to select the most appropriate systems from an energetic standpoint for different types of applications (industrial or service) as well as the ability to analyse the behaviour of a system in operation and make a diagnosis on the operating system.
- The student has the knowledge, skills and elements of analysis and judgment necessary to consider a pre-feasibility study, related to the use of hybrid systems in different industrial sectors and services.

Related activities:
12. Exercise on hybrid systems

Full-or-part-time: 16h 40m
Theory classes: 4h
Practical classes: 2h
Guided activities: 2h
Self study : 8h 40m

Research and development

Description:
- Main lines of research in the field of technologies for harnessing renewable energy.
- Main lines and business opportunities associated with developing new products and services in the field of technologies for harnessing renewable energy.

Specific objectives:
- Know the main lines of research in the field of technologies for harnessing renewable energy.
- Know the main lines and business opportunities associated with developing new products and services in the field of technologies for harnessing renewable energy.

Related activities:
13. Exercise on research and development

Full-or-part-time: 16h 40m
Theory classes: 4h
Practical classes: 2h
Guided activities: 2h
Self study : 8h 40m

ACTIVITIES

6. Exercise on wind energy

Description:
Independent exercise on wind energy.

Specific objectives:
- Deepen knowledge and its application in practical cases.
- Develop the skills of the student in the selection and evaluation of equipment and of installation equipment.

Material:
- Description of the exercise.
- References.

Delivery:
Report of the results.

Full-or-part-time: 6h 20m
Self study: 4h 20m
Guided activities: 1h
Practical classes: 1h

Activities

Description:
Analyze the content of the lectures.
Work in groups the assignements per session, carrying out an exercise on units, energy (primary, final and useful) and renewable resources. Identification of innovative technologies, problems related with the content, etc.
Work in groups the project for a renewable energy case, using HOMER to describe the sources of energy, the energy demand and the basic costs of the concept.
Work in groups an identification of the most promising innovation you perceive in the field of renewable energies. You should describe in a compact way the innovation, explaining why it is an architectural, a disruptev or a radical innovation.
Active participation in a round table with industry experts.

Specific objectives:
Deepen knowledge and its application in solving basic exercises of calculations of quantities of energy.

Material:
- Slides with the content of the lectures.
- Documentation and tutrials about HOMER.
- Description of the exercises.
- References and data sources.

Delivery:
Reports.

Full-or-part-time: 6h 20m
Self study: 4h 20m
Guided activities: 1h
Practical classes: 1h

3. Exercise on solar energy

Description:
Individual exercise of an assessment and analysis of a solar resource.

Specific objectives:
Deepen knowledge and its application in practical cases related to the use of solar energy in different industrial sectors and of services for the assessment of available resources.

Material:
- Description of the exercise.
- References.

Delivery:
Report of the results.

Full-or-part-time: 6h 20m
Self study: 4h 20m
Guided activities: 1h
Practical classes: 1h

4. Exercise on solar thermal energy

Description:
Independent exercise on solar thermal energy.

Specific objectives:
- Deepen knowledge and its application in practical cases.
- Develop the skills of the student in the selection and evaluation of equipment and of installation equipment.

Material:
- Description of the exercise.
- References.

Delivery:
Report of the results.

Full-or-part-time: 6h 20m
Self study: 4h 20m
Guided activities: 1h
Practical classes: 1h

5. Exercise on solar photovoltaic energy

Description:
Independent exercise on solar photovoltaic energy.

Specific objectives:
- Deepen knowledge and its application in practical cases.
- Develop the skills of the student in the selection and evaluation of equipment and of installation equipment.

Material:
- Description of the exercise.
- References.

Delivery:
Report of the results.

Full-or-part-time: 6h 20m
Self study: 4h 20m
Guided activities: 1h
Practical classes: 1h

7. Exercise on hydropower and ocean energy

Description:
Independent exercise on hydropower and ocean energy.

Specific objectives:
- Deepen knowledge and its application in practical cases.
- Develop the skills of the student in the selection and evaluation of equipment and of installation equipment.

Material:
- Description of the exercise.
- References.

Delivery:
Report of the results.

Full-or-part-time: 6h 20m
Self study: 4h 20m
Guided activities: 1h
Practical classes: 1h

8. Exercise on geothermal energy

Description:
Independent exercise on geothermal energy.

Specific objectives:
- Deepen knowledge and its application in practical cases.
- Develop the skills of the student in the selection and evaluation of equipment and of installation equipment.

Material:
- Description of the exercise.
- References.

Delivery:
- Report of the results.

Full-or-part-time: 6h 20m
Self study: 4h 20m
Guided activities: 1h
Practical classes: 1h

9. Exercise on biomass and waste

Description:
Independent exercise on biomass and waste.

Specific objectives:
- Deepen knowledge and its application in practical cases.
- Develop the skills of the student in the selection and evaluation of equipment and of installation equipment.

Material:
- Description of the exercise.
- References.

Delivery:
Report of the results.

Full-or-part-time: 6h 20m
Self study: 4h 20m
Guided activities: 1h
Practical classes: 1h

10. Exercise on biogas and biofuels

Description:
Independent exercise on biogas and biofuels.

Specific objectives:
- Deepen knowledge and its application in practical cases.
- Develop the skills of the student in the selection and evaluation of equipment and of installation equipment.

Material:
- Description of the exercise.
- References.

Delivery:
Report of the results.

Full-or-part-time: 6h 20m
Self study: 4h 20m
Guided activities: 1h
Practical classes: 1h

11. Exercise on hydrogen and fuel cells

Description:
Independent exercise on hydrogen and fuel cells.

Specific objectives:
- Deepen knowledge and its application in practical cases.
- Develop the skills of the student to consider a pre-feasibility study, related to the use of hydrogen and fuel cells in different industrial sectors and services.

Material:
- Description of the exercise.
- References.

Delivery:
Report of the results.

Full-or-part-time: 6h 20m
Self study: 4h 20m
Guided activities: 1h
Practical classes: 1h

12. Exercise on hybrid systems

Description:
- Independent exercise on hybrid systems.
o Dimension and optimisation of a hybrid system to generate electricity independently.

Specific objectives:
- Deepen knowledge and its application in practical cases.
- The student has the knowledge, skills and elements of analysis and judgment necessary to consider a pre-feasibility study, related to the use of hybrid systems in different industrial sectors and services.

Material:
- Description of the exercise.
- References.

Delivery:
Report of the results.

Full-or-part-time: 12h 40m
Self study: 8h 40m
Guided activities: 2h
Practical classes: 2h

13. Exercise on research and development

Description:
Independent exercise on research and development.

Specific objectives:
The student is capable of making a sketch on the approach of a line of research or of product development.

Material:
- Description of the exercise.
- References.

Delivery:
Report of the results.

Full-or-part-time: 12h 40m
Self study: 8h 40m
Guided activities: 2h
Practical classes: 2h

GRADING SYSTEM

Mark = written tests mark*0.5 + weekly assignments mark*0.25 + Homer project mark*0.20 + innovation exercise *0.05

Written tests. 50%: 3 questions per session with 4 answers each (only one valid). The weight of every part is proportional to the number of sessions.

Assignments & Homer project:

- Teams of 4 members will be formed to work the assignments.
These teams will be formed by initiative of the students. Strongly recommended combining different bachelor backgrounds and different nationalities.
The same mark will be assigned to all the members of the team.

25 % Assignments:
- Sessions' assignments, each session having the same weight. These session assignments will be done by the teams of 4 or individually, according to the definition of the assignment by each professor, for each session of the course. This means you will work 11 assignments for the different technologies of the course.

20 %: project based in HOMER for the design of a hybrid renewable system, developed by the team of 4.
The topic of the project is chosen by the teams, using technologies described in the course. A design thinking approach will be used:
1st step: definition (max 1 page) (20 %)
2nd step: description (max 5 pages) (40 %)
3rd step: video pitch (max 3 minutes) (40 %)

5 %: proposal, by the team of 4 or individual, of a radical, disruptive or architectural innovation related with the technologies of the course. Your proposal will be ranked by the experts of the Round Table.

Evaluation with the re-exam
Re-exam must be taken by the students that have not passed the course during the regular period.
Re-exam must be done for the whole course in any case.
The mark of the course when taking the re-exam will be calculated as the mark of the re-exam.

RESOURCES

Other resources:
Documentation is prepared by the teachers of the course and available in Atenea.
The documentation is updated every year.