Course guide
295917 - RETAA - Renewable Energy Technologies and Applications

Last modified: 02/10/2025

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

Degree: BACHELOR'S DEGREE IN BIOMEDICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN ENERGY ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2025 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: HERMINIO MARTINEZ GARCIA

Others: Primer quadrimestre:
AGNÈS LOMASCOLO PUJADÓ - Grup: M1

PRIOR SKILLS

General courses in the first years of an engineering degree.

REQUIREMENTS

General courses in the first years of an engineering degree.

TEACHING METHODOLOGY

Two theory classes per week with a total of 4.0 h/week, which encompass matter of theory, problems, and laboratory classes.

Additionally, throughout the semester, different classes will be held (schedule will be announced at the beginning of term) with the whole group or part thereof in order to explain, develop and assess cross (generic) competences assigned to the subject.

The course uses:

- Lecture methodology by 40%.
- Individual work by 30% .
- Work in groups by 30 %.

The student will develop, in groups of, at most, 2 students, a project of the course design, simulation, and/or implementation related to the content of the course.

LEARNING OBJECTIVES OF THE SUBJECT

- CEENE-20: Evaluar y comparar la capacidad y potencialidad energética de los distintos recursos energéticos disponibles.
- CEENE-21: Poder dar explicaciones relativas a los modelos energéticos actuales, las distintas posibilidades de reducir su impacto global y las implicaciones entre energía y sociedad.
- CEENE-210: Dimensionar y diseñar sistemas de producción de energía basados en energías renovables.
- CEENE-22: Determinar la mejor forma de almacenamiento de energía frente a un caso concreto.
- CEENE-22: Poder hacer un análisis y simulación de un determinado sistema energético.

STUDY LOAD

Type	Hours	Percentage
Hours small group	30,0	50.00
Hours large group	30,0	50.00

Total learning time: 60 h

CONTENTS

1.- Introduction to Solar Energy. Passive Solar Energy and Solar or Bioclimatic Architecture.

Description:
1.1.- Introduction. The Sun, an inexhaustible source of energy.
1.2.- Preliminary ideas about solar energy.
1.2.1.- Advantages and disadvantages of solar energy.
1.3.- Classification of solar energy systems.
1.3.1.- Solar or bioclimatic architecture.
1.3.2.- Solar thermal energy (STE).
1.3.3.- Photovoltaic solar energy (PVE).
1.3.4.- Technical and economic aspects.
1.4.- Passive solar energy and solar or bioclimatic architecture: introduction and current situation.
1.4.1.- Technologies and applications of bioclimatic architecture.
1.4.2.- Penetration: solar incidence and shadows.
1.4.3.- Heating strategies with bioclimatic architecture.
1.4.4.- Ventilation and cooling strategies with bioclimatic architecture.
1.4.5.- Systems for regulating and controlling solar radiation penetration.
1.5.- Preliminary ideas on the static conversion of electrical energy in renewable systems.
1.5.1.- Signal processing and energy processing: differences.
1.5.2.- DC-DC, DC-AC, AC-AC, and AC-AC conversions.
1.5.3.- Output voltage regulation: voltage regulators.
1.5.4.- The control loop in output voltage regulation.
1.6.- Integration of electrical energy systems.

Full-or-part-time: 7h
Theory classes: 2h
Self study : 5h

2.- Elements of Photovoltaic Solar Energy Systems for Electrical Generation.

Description:
2.1.- Introduction to photovoltaic solar energy systems.
2.1.1.- Objectives of a photovoltaic solar installation.
2.1.2.- Applications of photovoltaic solar energy.
2.1.3.- Block diagram of a photovoltaic solar energy collection system.
2.1.4.- Subsystems of a photovoltaic solar installation.
2.1.5.- Technological development and current situation.
2.1.6.- Configuration of photovoltaic solar energy installations: off-grid installations, and installations connected to the electrical grid.
2.2.- Solar collection subsystem.
2.2.1.- Introduction and general considerations.
2.2.2.- Photovoltaic modules: classification, electrical and mechanical characteristics, and commercial models.
2.2.3.- Efficiency of modules.
2.2.4.- Form factor.
2.2.5.- Energy generated by a solar panel.
2.2.6.- Orientation and inclination. Determination of the appropriate inclination for photovoltaic solar modules.
2.2.7.- Determination of shadows and minimum distance between modules.
2.2.8.- Mechanical support structure.
2.2.9.- Types of connections in photovoltaic solar collection systems: series, parallel, and mixed.
2.2.10.- Shadow calculation in solar collector fields.
2.3.- Description of other components and equipment in photovoltaic solar energy collection systems.
2.3.1.- General considerations.
2.3.2.- Energy storage or battery subsystem: types, capacity, depth of discharge, lifespan, battery association.
2.3.3.- Electronic voltage regulators: types, internal structure, commercial data, etc.
2.3.4.- Electronic voltage inverters: types, internal structure, commercial data, etc.
2.3.5.- Electrical wiring.
2.3.6.- Component placement.
2.3.7.- Other elements and energy integration: wind turbines for energy support.

Full-or-part-time: 13h
Theory classes: 6h
Laboratory classes: 2h
Self study : 5h

3.- Sizing in Solar Photovoltaic Energy Installation Projects for Electrical Generation.

Description:
3.1.- Introduction. Design guide.
3.2.- Data for sizing a solar photovoltaic energy installation.
3.2.1.- General considerations.
3.2.2.- Usage conditions. Maximum consumption.
3.2.3.- Latitudes.
3.2.4.- Climatic conditions: radiation on horizontal surface and on inclined surface.
3.2.5.- Solar peak hours (SPH).
3.2.6.- Autonomy days.
3.3.- Sizing of solar photovoltaic energy installations.
3.3.1.- Energy demand evaluation.
3.3.2.- Solar energy contribution evaluation.
3.3.3 .- Definition of the generator field power.
3.3.4.- Determination of the number of photovoltaic solar panels in series and parallel.
3.3.5.- Sizing of off-grid installations: DC supply, simultaneous DC and AC supply, and AC supply.
3.3.6.- Sizing of grid-connected installations.
3.3.7.- Use of specific software for the sizing of solar photovoltaic energy installations.
3.3.8.- Legislation and regulations to comply with: CTE (Technical Building Code), IDAE (Institute for the Diversification and Saving of Energy) technical specifications, and REBT (Low Voltage Electrotechnical Regulations) Complementary Technical Instructions.
3.4.- Examples of sizing and projects for solar photovoltaic energy installations for electrical generation.
3.4.1.- Sizing installations for single-family homes: off-grid, grid-connected, permanent use, seasonal (summer or winter) use, etc.
3.4.2.- Sizing an off-grid installation for a block of houses.
3.4.3.- Sizing of grid-connected installations for voltage electrical grids.
3.5.- Solar photovoltaic energy installations for water pumping.
3.5.1.- Components of water pumping systems.
3.5.2.- Sizing of water pumping systems with and without battery subsystems.

Full-or-part-time: 20h
Theory classes: 7h
Laboratory classes: 3h
Self study : 10h

4.- Components of Wind Energy Systems for Electricity Generation.

Description:
4.1.- Introduction to wind power systems for electricity generation.
4.2.- Wind as a source of renewable energy.
4.3.- Classification of wind turbines.
4.3.1.- Horizontal axis wind turbines (HAWT).
4.3.2.- Vertical axis wind turbines (VAWT).
4.4.- Theoretical foundations of wind energy.
4.4.1.- Available wind power and wind energy potential.
4.4.2.- Theoretical maximum wind power. Betz limit.
4.4.3.- Power at the rotor shaft.
4.4.4.- Wind turbine wakes.
4.5.- Power balance and flow in a wind turbine.
4.5.1.- Mechanical power and efficiencies.
4.5.2.- Electrical power and efficiencies.
4.5.3.- Overall efficiency and power coefficient of the wind turbine.
4.6.- Wind data and information.
4.6.1.- Wind rose for origin and power.
4.7.- Terrain orography and wind obstacles.
4.8.- Surface roughness and wind profile.
4.9.- Mounting height and siting of the wind turbine.
4.9.1.- General criteria for site selection.
4.9.2.- Steps to follow in the site assessment of a wind turbine.

Full-or-part-time: 12h
Theory classes: 5h
Laboratory classes: 2h
Self study : 5h

5.- Sizing of Wind and Hybrid Power Systems for Electricity Generation. Support of Electric Power Systems Through Wind Energy.

Description:
5.1.- General considerations.
5.2.- Introduction. Design guidelines.
5.3.- Data required for the sizing of a wind energy installation.
5.3.1.- Wind turbine power curve provided by the manufacturer.
5.3.2.- Wind behavior modeling. Wind distribution.
5.3.3.- Acquisition of wind behavior data.
5.3.4.- Wind evolution with height. Hellmann power law.
5.3.5.- Variation of Weibull distribution parameters with height.
5.4.- Calculation methodology for expected wind energy production.
5.5.- Sizing and estimation of wind energy output.
5.6.- Types of wind energy installations.
5.6.1.- Stand-alone wind installation.
5.6.2.- Hybrid stand-alone wind–photovoltaic installation with auxiliary generator.
5.6.3.- Grid-connected wind installation.
5.7.- Approximate costs of a stand-alone installation.
5.8.- Examples of wind and hybrid energy system sizing. Support of electric power systems through wind energy.
5.8.1.- Introduction. Hybrid renewable generation systems for electricity.
5.8.2.- Sizing of installations for single-family homes: off-grid, grid-connected, for permanent or seasonal use (summer or winter), etc.
5.8.3.- Sizing of an off-grid installation for a multi-family building.
5.8.4.- Sizing of water pumping systems with and without battery storage.
5.8.5.- Sizing of installations connected to the electricity distribution network.
5.8.6.- Other relevant examples.

Full-or-part-time: 19h
Theory classes: 7h
Laboratory classes: 2h
Self study : 10h

6.- Control Subsystems, Energy Measurement, and Protections in Photovoltaic, Wind, and Hybrid Installations.

Description:
6.1.- General considerations.
6.2.- Measurement of environmental magnitudes.
6.2.1.- Solar radiation measurement.
6.2.2.- Ambient temperature measurement.
6.2.3.- Wind speed measurement.
6.3.- Measurement of electrical magnitudes: voltage, current, etc.
6.4.- Electric energy meters.
6.5.- Data acquisition systems.
6.6.- Protection devices: fuses, circuit breakers (ICP, IGA, PIAs, etc.).
6.7.- Leakages in electrical installations and residual current devices (RCDs).
6.8.- Grounding systems. Installation of grounding rods.
6.9.- Lightning protection in solar installations.

Full-or-part-time: 7h
Theory classes: 2h
Self study : 5h

7.- Electrical Cabling Calculations for Photovoltaic, Wind, and Hybrid Installations.

Description:
7.1.- Introduction.
7.2.- Cross-sectional area calculation: for DC and AC power supply.
7.3.- Low Voltage Electrotechnical Regulation (REBT).
7.3.1.- Complementary Technical Instructions of the REBT.
7.4.- Cable selection.
7.5.- Representation in diagrams.
7.6.- Commercial selection of cabling.
7.7.- Cabling in a residential dwelling.
7.8.- Calculation and diagram examples.

Full-or-part-time: 14h
Theory classes: 4h
Self study : 10h

8.- Budgets and Project Documentation for Photovoltaic, Wind, and Hybrid Installations.

Description:
8.1.- General considerations.
8.2.- Architectural integration in buildings: degrees of integration and mounting details for solar collectors and panels.
8.3.- Types of budgets.
8.4.- Project and technical report.
8.5.- Standardized investment, operation, and maintenance costs.

Full-or-part-time: 12h
Theory classes: 2h
Self study : 10h

9.- Introduction to Solar Thermal Energy Systems (STE).

Description:
9.1.- Introduction. Objectives of a solar thermal energy (STE) installation.
9.2.- Applications of solar thermal energy.
9.3.- Classification of solar thermal energy systems.
9.3.1.- Low-temperature solar thermal energy with direct collection: solar thermal systems for domestic hot water (DHW).
9.3.2.- Medium-temperature solar thermal energy with low concentration ratio collection.
9.3.3.- High-temperature solar thermal energy with high concentration ratio collection: central tower solar power plants (central receiver system, CRS).
9.4.- Block diagram of a solar thermal energy collection system.
9.5.- Subsystems of a solar thermal installation.
9.6.- Technological development and current status.

Full-or-part-time: 13h
Theory classes: 1h
Laboratory classes: 2h
Self study : 10h

10.- Components of Solar Thermal Energy Systems with Direct Collection.

Description:
10.1.- Solar collection subsystem.
10.1.1.- Introduction.
10.1.2.- Instantaneous efficiency of a solar collector.
10.1.3.- Types of connections in solar thermal collection systems: series, parallel, and mixed.
10.1.4.- Balancing of the solar collector field.
10.1.5.- Connection of the solar collector field.
10.1.6.- Shadow calculation in solar collector fields.
10.2.- Description of other components and equipment in solar thermal energy collection systems.
10.2.1.- Heat exchange or heat transfer subsystem.
10.2.2.- Storage or accumulation subsystem.
10.2.3.- Distribution subsystem and hydraulic circuits.
10.2.4.- Other elements: working fluids, expansion vessels, frost protection, insulation, etc.

Full-or-part-time: 9h
Theory classes: 2h
Laboratory classes: 2h
Self study : 5h

11.- Projects and Sizing of Solar Thermal Energy Installations with Direct Collection.

Description:
11.1.- Introduction. Design guidelines.
11.2.- Calculation of the monthly energy demand of a building. Occupancy levels.
11.3.- Calculation of available monthly solar radiation. Useful solar hours.
11.4.- Orientation and inclination. Determination of the optimal inclination for solar collectors.
11.5.- Correction of solar energy incident on the solar collectors.
11.6.- Calculation of the necessary solar collector area.
11.7.- Calculation of the monthly energy demand.
11.8.- Calculation of the expected monthly solar production.
11.9.- Calculation of the necessary storage volume.
11.10.- Calculation of the auxiliary heating power.
11.11.- Installation of the domestic hot water (DHW) system.
11.12.- Use of nomograms for the sizing of solar thermal energy installations.
11.13.- Use of specific software for the sizing of solar thermal energy installations.
11.14.- Legislation and regulations to be complied with: CTE (Technical Building Code), IDAE (Institute for the Diversification and Saving of Energy) technical specifications, regional and local legislation (municipal ordinances).

Full-or-part-time: 9h
Theory classes: 2h
Laboratory classes: 2h
Self study : 5h

12.- Examples of Sizing Solar Thermal Energy Installations with Direct Collection.

Description:
12.1.- Sizing installations for single-family homes: permanent occupation, occasional (seasonal), near the sea, in the mountains, etc.
12.2.- Sizing an installation for a block of houses.
12.3.- Sizing an installation for a building with a mandatory solar contribution.
12.4.- Sizing for water heating in sports facilities and swimming pools: outdoor and indoor pools.
12.5.- Climate control: sizing for heating using radiant floor systems.
12.6.- Cooling production and absorption refrigeration.

Full-or-part-time: 2h
Theory classes: 2h

13.- Control Subsystems, Energy Measurement, Protection Subsystems, and Conventional Energy Support in Solar Thermal Installations.

Description:
13.1.- General considerations.
13.2.- Solar radiation measurement.
13.3.- Ambient temperature measurement.
13.4.- PLC controllers for solar thermal energy installations: control panels.
13.4.1.- Commercial examples.
13.5.- Conventional energy support systems in single-family homes.
13.5.1.- Commercial examples.
13.6.- Conventional energy support systems in collective installations.
13.6.1.- Commercial examples.
13.7.- Safety and maintenance aspects. Prevention of legionellosis (anti-legionella maintenance).

Full-or-part-time: 7h
Theory classes: 2h
Self study : 5h

14.- Pipelines and Pressure Losses in Solar Thermal Energy Installations.

Description:
14.1.- Introduction.
14.2.- Types of pipelines: copper, plastic, galvanized steel, and black steel pipes.
14.3.- Calculation of pipe diameter.
14.4.- Typical values for pipelines and tubes in solar thermal installations.
14.5.- Typical values of pressure losses and flow rates in solar thermal installations.
14.6.- Typical values of fluid velocity in solar thermal installations.
14.7.- Pressure losses.
14.8.- Determination of pressure losses in pipelines and tubes.
14.9.- Determination of pressure losses in accessories and special fittings.
14.10.- Correction factors required for pressure loss calculations.
14.11.- Approximate determination of pressure losses in pipelines.
14.12.- Required power of electrocirculation pumps.
14.13.- Design examples.

Full-or-part-time: 6h
Theory classes: 1h
Self study : 5h

GRADING SYSTEM

The grade or scoring of the course will be carried out according to:

• Midterm exams: 20 %.
• Final exam: 40 %.
• Course project (project to design, simulate, and implement analog electronic systems): 20 %.
• Laboratory activities and tests: 20 %.

All these tasks will also serve to assess the cross (generic) competences assigned to the course.

This course does not have re-assessment test ("prova de reavaluació").

EXAMINATION RULES.

The implementation of the different tests consists of:

• Midterm exams: written tests, theoretical or sizing problems of solar energy testing, and analysis and/or synthesis (design) of renewable energy systems.
• Final exam: written, theoretical and/or sizing problems of solar energy test, and analysis and synthesis (design) of renewable energy systems.
• Course project: The course project will involve conducting course design work, sizing and/or simulation related to the contents of the subject.
• Activities, testing and laboratory experiments: Laboratory experiences and activities on renewable energy systems.

Thanks to all these tasks, the cross (generic) competences assigned to the course will be also evaluated.

BIBLIOGRAPHY

Basic:

- Martínez García, Herminio. Apuntes de clase sobre energías renovables. 2025.