

Course Unit	Renewable Energies	Field of study	Energy
Master in	Industrial Engineering - Electrical Engineering	School	School of Technology and Management
Academic Year	2022/2023	Year of study	1
Type	Semestral	Semester	1
Level	2-1	ECTS credits	6.0
Code	9572-355-1101-00-22		
Workload (hours)	162	Contact hours	T 30 TP - PL 30 TC - S - E - OT - O -

T - Lectures; TP - Lectures and problem-solving; PL - Problem-solving, project or laboratory; TC - Fieldwork; S - Seminar; E - Placement; OT - Tutorial; O - Other

Name(s) of lecturer(s) Luís Manuel Frolen Ribeiro

### Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:

1. Understand the working principles of the different components and technologies of renewable sources and assessment methods of endogenous resources.
2. Identify economical and environmental value of renewable sources.
3. Understand the national plan for renewable energies
4. Characterize the power systems and to know the structure of electrical grids, in particular the Portuguese case.
5. Understand the fundamentals concerning the integration of the technologies commonly used to generate electricity from renewable sources, mainly hydropower, photovoltaic and wind systems.

### Prerequisites

Before the course unit the learner is expected to be able to:

1. Notions of classical thermodynamics.
2. Analyse linear circuits in both direct and alternate current

### Course contents

Energy and Environment. Renewable energy sources. Wind Energy. Hydro power. Solar thermal. Portuguese plan for renewable energies for electricity generation. Characterization of power systems. Organization and management of power systems. Solar photovoltaic, wind power and small hydropower energy systems.

### Course contents (extended version)

1. Introduction
  - Energy, definition and concepts
  - Energy and progress; energy intensity
  - Dominant cultural energy; change in energy paradigm; energy policy vectors
2. Energy and Environment
  - Traditional fuels
  - Environmental problems associated with traditional fuels
  - Energy dilemma in modern societies
  - Energy saving measures
3. Renewable energy sources
  - Renewable/alternative; concept of "renewable"
  - Origin and renewable types - technologies and maturity degree
  - Future global energy positioning
4. Wind Energy
  - Origin, general circulation and local effects
  - Wind regime characterisation, wind potential
  - Conversion principles, rotor aerodynamics
  - Main characteristics of a wind turbine
  - Energy converted by a wind turbine; isolated and integrated set-ups
5. Hydro power
  - Available technologies
  - Set-up classification
  - Hydric regime and resource assessment
  - Basic project criteria
  - Main hydro turbine types and application; energy converted by an hydropower system
6. Solar thermal
  - Geometry and solar resources
  - Radiation in inclined surfaces
  - Thermal solar panels with low or no concentration - types and applications
  - Thermal solar panels for heating water
  - Thermal solar panels for environmental heating, cooling and industrial processes
  - Calculation methods f-chart, fi-chart and fi, f-chart
7. National plan for renewable energies concerning power generation
  - European policies for energy
  - Portuguese strategy for energy
  - Remuneration of electricity from renewable energy sources
  - Regulation issues concerning power generation from renewable energy sources
8. Revision of the fundamental concepts of power systems
  - Power and energy
  - Load diagram
  - Power in electrical power systems: Active, reactive and complex power
  - Three-phase systems: Voltage, current and power in symmetrical systems
  - Load characterization: Typology and elasticity
9. Power systems characterization
  - The power system: Structure, components, requirements and single-line diagram
  - Electrical grids: Purpose, nominal voltage and topology
  - The Portuguese electrical network
10. Organization and management of power systems
  - Characteristics of electricity
  - Organizational schemes of electrical sector
  - Regulation of the electrical sector
  - Iberian electricity market
  - Frequency regulation, voltage support, power reserves and service restoration
  - Service quality on power systems
11. Photovoltaic systems
  - Technical and economical issues

**Course contents (extended version)**

- The photovoltaic effect
  - Mathematical model of the solar cell
  - Applications of photovoltaic systems
  - Main criteria for sizing photovoltaic systems
  - Main components of photovoltaic systems
  - Estimation of the generated power
12. Wind power plants
- Generators
  - Main characteristics and working principles of the generators
  - Interconnection to Electrical grid

**Recommended reading**

1. "Renewable Energy – Power for a Sustainable Future", Boyle, G. , Oxford University Press, 2004
2. "Energias Renováveis, a Opção Inadiável", Manuel Collares-Pereira; SPES - Sociedade Portuguesa de Energia Solar, 1998.
3. "Redes de Energia Eléctrica: uma Análise Sistémica", José Pedro Sucena Paiva, IST Press, 2005
4. "Photovoltaics for Professionals: Solar Electric Systems Marketing, Design and Installation", Falk Antony, Christian Dürschner, Karl-Heinz Remmers, Earthscan Publications Ltd. , June 2007
5. "Embedded Generation", N. Jenkins, R. Allan, P. Crossley, D. Kirchen, G. Strbac, IEE Power and Energy Series, 31, London, 2000

**Teaching and learning methods**

Lectures of explanation of concepts and methodologies for the understanding the course contents. Practices: lectures will rely on Project Based Learning methodology with a common project for different groups in the class. Each group will make regular presentations to the classroom.

**Assessment methods**

- Alternative 1 - (Regular, Student Worker) (Final, Supplementary, Special)
  - Development Topics - 50% (Group work on specific renewable energy technology. Assignment 1)
  - Development Topics - 50% (Individual assignments over the classroom material. Assignment 2)

**Language of instruction**

Portuguese, with additional English support for foreign students.

**Electronic validation**

Lúis Manuel Frolen Ribeiro	João Eduardo Pinto Castro Ribeiro	José Alexandre de Carvalho Gonçalves	Paulo Alexandre Vara Alves
28-09-2022	28-09-2022	04-10-2022	07-11-2022