

Academic Year: ( 2023 / 2024 )

Review date: 08-06-2023

Department assigned to the subject: Electrical Engineering Department

Coordinating teacher: RODRIGUEZ AMENEDO, JOSE LUIS

Type: Compulsory ECTS Credits : 6.0

Year : 1 Semester : 1

## REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Circuit analysis  
Electrical machines  
Electrical drives  
Control systems

## OBJECTIVES

The specific objectives are summarized in:

- Acquire adequate knowledge of wind energy technology and use the exact terminology of the components for the most common applications, including offshore wind and offshore, as well as small wind turbines.
- Follow the technological evolution of wind energy and have prospective knowledge of this evolution.
- Understand and use the fundamental physical equations that allow converting wind energy into mechanical and electrical energy.
- Understand and apply the main systems design criteria of modern wind turbines.
- Describe all types of wind turbines and understand the main mathematical models for the most relevant types, with special emphasis on different control strategies.
- Identify the main wind turbine manufacturers, and adequately analyze and compare the technical specifications of their products.
- Understand the results of software packages that use wind turbine models for economic evaluation or analysis of power systems.

## DESCRIPTION OF CONTENTS: PROGRAMME

### 1. Introduction

- History of the development of wind energy
- Statistics of the development of wind energy
- Current manufacturers and models of wind turbines

### 2- Wind resource and power generation

- Wind resource monitoring
- Analysis of the wind resource
- Annual energy production of a wind farm

### 3- Aerodynamics of wind systems

- Introduction to lift and thrust forces
- Triangle of speeds and relative speed
- Aerodynamic models in wind energy conversion systems.
- Power efficiency coefficient:  $C_p$
- Calculation of the power and torque developed by the blade

### 4- Description of the main components and types of terretr wind energy conversion systems

- Classification of wind turbines
- Main components
- Mechanical components

- Electric components
- Control systems
- Types of wind systems

#### 5- Electrical components of wind energy conversion systems

- Power transformers
- Electric generators
- Power electronics
- Settings

#### 6- Control systems in wind turbines

- Blade pitch control
- Torque control
- Speed control
- Simulation model of a fixed speed system
- Simulation model of a variable speed system

#### 7- Type 1 wind energy conversion system

- General description
- Aerodynamic and mechanical components
- Electrical components
- Control systems
- Simulation models

#### 8- Type 2 wind energy conversion system

- General description
- Aerodynamic and mechanical components
- Electrical components
- Control systems
- Simulation models

#### 9- Type 3 wind energy conversion system

- General description
- Aerodynamic and mechanical components
- Electrical components
- Control systems
- Simulation models

#### 10- Type 4 wind energy conversion system

- General description
- Aerodynamic and mechanical components
- Electrical components
- Control systems
- Simulation models

### LEARNING ACTIVITIES AND METHODOLOGY

The teaching method will consist of lectures and the development of a project chosen by the student team ("project based learning").

The last classes will be presented by the students with projects that develop along the whole course.

Problems will be solved with the use of specific software packages.

### ASSESSMENT SYSTEM

<b>% end-of-term-examination:</b>	0
<b>% of continuous assessment (assignments, laboratory, practicals...):</b>	100

In the ordinary call the students will have to deliver a report of the chosen project, present the results and take an oral final exam, which will compute 100% of the mark of the continuous evaluation.

In the extraordinary call students will have to take a written exam, and the percentage weight of this exam in the final grade will be 100%.

### BASIC BIBLIOGRAPHY

- James F. Manwell, Jon G. McGowan, Anthony L. Roger Wind Energy Explained: Theory, Design and Application, 2nd Edition, Wiley, 2009
- John Dalsgaard Sørensen, Jens N Sørensen Wind Energy Systems: Optimising Design and Construction for Safe and Reliable Operation, Elsevier, 2010
- José Luis Rodríguez Amenedo, Juan Carlos Burgos, Santiago Arnalte Sistemas Eólicos de Producción de Energía Eléctrica, Rueda, 2003
- Mohamed A. El-Sharkawi Wind Energy: An Introduction, CRC Press, 2015
- Olimpo Anaya-Lara, Nick Jenkins, Janaka Ekanayake, Phill Cartwright, Michael Hughes Wind Energy Generation: Modelling and Control, Wiley, 2009
- Thomas Ackermann (Editor) Wind Power in Power Systems, 2nd Edition, Wiley, 2012

#### ADDITIONAL BIBLIOGRAPHY

- Bin Wu, Yongqiang Lang, Navid Zargari, Samir Kouro Power Conversion and Control of Wind Energy Systems, Wiley, 2011
- Gonzalo Abad, Jesus Lopez, Miguel Rodriguez, Luis Marroyo, Grzegorz Iwanski Doubly Fed Induction Machine: Modeling and Control for Wind Energy Generation, Wiley-IEEE Press, 2011
- Olimpo Anaya-Lara, David Campos-Gaona, Edgar Moreno-Goytia, Grain Adam Offshore Wind Energy Generation: Control, Protection, and Integration to Electrical Systems, Wiley, 2014
- R Clark Small Wind, 1st Edition Planning and Building Successful Installation, Elsevier, 2013
- Tony Burton, Nick Jenkins, David Sharpe, Ervin Bossanyi Wind Energy Handbook, 2nd Edition, Wiley, 2011