Wind power generation systems

Academic Year: (2020 / 2021) **Review date: 16-12-2020**

Department assigned to the subject: Electrical Engineering Department

Coordinating teacher: SANTOS MARTIN, DAVID

Type: Compulsory ECTS Credits : 6.0

Year : 1 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

It is desirable that students have knowledge of power systems: circuit theory and electrical machines. Moreover, it is recommended a basic knowledge of control systems and electric drives.

OBJECTIVES

CB6 Possess and understand knowledge that provides a basis or opportunity to be original in the development and / or application of ideas, often in a research context
CB7 That students know how to apply the acquired knowledge and their ability to solve problems in new or little-known environments within broader (or multidisciplinary) contexts related to their area of ¿¿study
CB8 That students are capable of integrating knowledge and facing the complexity of formulating judgments based on information that, being incomplete or limited, includes reflections on social and ethical responsibilities linked to the application of their knowledge and judgments
CB9 That students know how to communicate their conclusions and the knowledge and ultimate reasons that support them to specialized and non-specialized audiences in a clear and unambiguous way
CB10 That students possess the learning skills that allow them to continue studying in a way that will be largely self-directed or autonomous.
1- Adquirir conocimientos adecuados de Energías renovables: recursos y tecnología. Deberán conocer con más detalle aquellas energías más frecuentes en nuestro entorno: energía eólica.
2- Adquirir conocimientos adecuados de Ingeniería eléctrica aplicados a la eólica.
3- Adquirir conocimientos adecuados de Gestión industrial de proyectos y empresas de energías renovables: eólica
4- Proyectar, calcular y diseñar productos, procesos, instalaciones y plantas de energías renovables: eólica.
5- Dirigir, planificar y supervisar equipos multidisciplinares que diseñen o ejecuten proyectos de energías renovables: eólica.
6- Realizar investigación, desarrollo e innovación en productos, procesos y métodos en relación con las energías renovables: eólica
7- Realizar la planificación estratégica y aplicarla a sistemas de energías renovables: eólica.
8- Gestionar técnica y económicamente proyectos, instalaciones, plantas, empresas y centros tecnológicos relacionados con las energías renovables: eólica.
9- Seguir la evolución tecnológica de las energías renovables (eólica) y tener conocimiento prospectivo de esta evolución.

Los estudiantes que completen con éxito este curso serán capaces de:

1- Resumir la historia de los aerogeneradores modernos justificando el desarrollo de la tecnología actual. Por otra parte, los estudiantes deben emplear la terminología exacta de los componentes para las aplicaciones más comunes, incluyendo eólica terrestre y marina (offshore), así como la de pequeños aerogeneradores.
2- Comprender y utilizar las ecuaciones físicas fundamentales que permiten convertir la energía eólica en energía mecánica y eléctrica.
3- Entender la tecnología, así como los sistemas principales criterios de diseño de los aerogeneradores modernos .
4-Describir todos los tipos de turbinas de viento y justificar sus principales características. Por otra parte, los estudiantes deben entender los principales modelos matemáticos para los tipos más relevantes, con especial énfasis en las diferentes estrategias de control.
5-Identificar los principales fabricantes de aerogeneradores, así como para analizar adecuadamente y

comparar las especificaciones técnicas de sus productos .
6-Comprender el impacto de la energía eólica, y los principales aspectos de los códigos de red desarrollados para mitigarlos.
7- Ser capaces de comprender los resultados de los paquetes de software que usan modelos de aerogeneradores para la evaluación económica o análisis de sistemas de potencia.
8- Desarrollar la capacidad para trabajar en equipo y promover la interacción de equipo de forma creativa para fomentar la contribución de todos los miembros con el fin de entregar los proyectos y tareas de ingeniería específicos
9- Conocer las necesidades sociales y energéticas de la energía eólica, así como de sus ventajas e inconvenientes
10- Conocer la normativa que afecta directamente al uso de la energía eólica a nivel mundial, así como de su origen, su vigencia y su aplicación, y en particular la IEC-61400.
11- Capacidad de dimensionado/diseño de plantas productoras de electricidad a partir de energía eólica.
12- Comprender cada una de las partes constitutivas de los los elementos que pueden conformar un aerogenerador.
13- Tener la capacidad para seleccionar los componentes más apropiados dentro de los comercialmente disponibles.
14- Conocer los requisitos exigidos para la integración de la energía eólica en la red eléctrica, y en los mercados de energía eléctrica.
15- Tener la capacidad de aplicar los conceptos de control y regulación en plantas de generación eólica.
16- Tener la capacidad de evaluar la viabilidad y gestionar proyectos y empresas de energía eólica.
17- Tener la capacidad de desarrollo de trabajos originales sobre un tema de la titulación, bajo supervisión, en el que se sinteticen las competencias adquiridas en las enseñanzas.

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1- Acquire adequate knowledge of renewable energies: resources and technology. They should know in more detail the most frequent energies in our environment: wind energy.
2- Acquire adequate knowledge of electrical engineering applied to wind.
3- Acquire adequate knowledge of industrial management of projects and renewable energy companies: wind
4- Project, calculate and design products, processes, facilities and renewable energy plants: wind.
5- Direct, plan and supervise multidisciplinary teams that design or execute renewable energy projects: wind.
6- Carry out research, development and innovation in products, processes and methods related to renewable energies: wind
7- Perform strategic planning and apply it to renewable energy systems: wind.
8- Technically and economically manage projects, facilities, plants, companies and technology centers related to renewable energy: wind.
9- Follow the technological evolution of renewable energies (wind) and have prospective knowledge of this evolution.

Students who successfully complete this course will be able to:

1- Summarize the history of modern wind turbines justifying the development of current technology. On the other hand, students must use the exact terminology of the components for the most common applications, including offshore wind and offshore, as well as small wind turbines.
2- Understand and use the fundamental physical equations that allow converting wind energy into mechanical and electrical energy.
3- Understand the technology, as well as the main systems design criteria of modern wind turbines.
4-Describe all types of wind turbines and justify their main characteristics. On the other hand, students must understand the main mathematical models for the most relevant types, with special emphasis on different control strategies.
5-Identify the main wind turbine manufacturers, as well as to adequately analyze and compare the technical specifications of their products.
6-Understand the impact of wind energy, and the main aspects of the network codes developed to mitigate them.
7- Be able to understand the results of software packages that use wind turbine models for economic evaluation or analysis of power systems.
8- Develop the ability to work as a team and promote team interaction in a creative way to encourage the contribution of all members in order to deliver specific engineering projects and tasks
9- Know the social and energy needs of wind energy, as well as its advantages and disadvantages
10- Know the regulations that directly affect the use of wind energy worldwide, as well as its origin, its validity and its application, and in particular IEC-61400.
11- Sizing capacity / design of electricity producing plants from wind power.

12- Understand each of the constituent parts of the elements that can form a wind turbine.
13- Having the ability to select the most appropriate components within the commercially available.
14- Know the requirements required for the integration of wind power in the electricity grid, and in the electricity markets.
15- Have the ability to apply the concepts of control and regulation in wind power plants.
16- Have the capacity to evaluate the feasibility and manage projects and wind energy companies.
17- Having the ability to develop original works on a subject of the degree, under supervision, in which the competences acquired in the teachings are synthesized.
18- Have the ability to exhibit and defend projects and their conclusions.

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
- Myths of wind energy

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: Cp
- Calculation of the power and torque developed by the blade

4- Description of the main components and types of terretre wind energy conversion systems
- Classification of wind turbines
- Main components
- Standard 61400
- Mechanical components
- Electric components
- Control systems
- Types of wind systems

5- Description of the main components and types of offshore wind energy conversion systems
- Anchorage systems
- Energy transport systems

6- Electrical components of wind energy conversion systems
- Power transformers
- Electric generators
- Power electronics
- Settings

7- Control systems in wind turbines
- Blade pitch control
- Torque control
- Speed ¿¿control
- Simulation model of a fixed speed system: type 1
- Simulation model of a variable speed system: type 3

8- Type 1 wind energy conversion system
- Statistics
- General description
- Aerodynamic and mechanical components
- Electrical components
- Control systems
- Simulation models

8- Type 2 wind energy conversion system
- Statistics
- General description

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

8- Type 3 wind energy conversion system
- Statistics
- General description
- Aerodynamic and mechanical components
- Electrical components
- Control systems
- Simulation models

8- Type 4 wind energy conversion system
- Statistics
- 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 master classes will be taught by professors from the Universidad Carlos III and invite some industry specialist in the issues.

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

Resolution of periodic questionnaires that will compute 25% of the continuous evaluation grade.
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 75% 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%.

% end-of-term-examination:	0
% of continuous assessment (assigments, laboratory, practicals…):	100

BASIC BIBLIOGRAPHY

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- John Dalsgaard Sørensen, Jens N Sørensen Wind Energy Systems: Optimising Design and Construction for Safe and Reliable Operation, Elsevier, 2010
- José Luis Rodriguez 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