Wind power generation systems

Academic Year: (2019 / 2020) **Review date: 30-04-2019**

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

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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 wind energy development
- Wind energy statitistics
- Current manufacturers and wind energy conversion systems models
- Wind power myths

2- Overview of wind turbine systems in onshore, offshore and small applications
- Aerodynamic
- Mechanical
- Electrical

3- Aerodynamics of Wind Turbines
- General concepts of aerodynamics
- One-dimensional momentum theory and the Betz limit
- Rotor performance calculation procedure
- An example of the rotor design process
- State of the art and future trends

4- Overview of Mechanics and Dynamics
- Wind turbine loads and design standard
- Dynamics of wind turbines
- Fatigue and resonant frequencies

5- Electrical aspects of Wind Energy Conversion Systems (WECS)
- Overview
- Power transformers
- Electric machines
- Power converters

6- WECS control systems and techniques
- Introduction
- Overview of WECS control systems
- Typical grid-connected turbine operation
- Supervisory control overview and implementation
- Dynamic control theory and implementation
- Classification of wind energy conversion systems

7- Type 1 wind energy conversion system
- Equivalent circuit for the squirrel-cage induction generator
- Power flow
- Electric torque
- Maximum power
- Maximum torque
- Assessment of Type 1 System
- Control and protection of type 1 System
- Reactive power of type 1 system
- Inrush current
- Turbine stability

8- Type 2 wind energy conversion system
- Equivalent circuit of type 2 generator
- Real power
- Electric torque
- Assessment of type 2 system
- Control and protection of Ttype 2 system
- Inrush current
- Turbine stability

9- Type 3 wind energy conversion system
- Equivalent circuit
- Simplified model
- Power flow
- Apparent power flow through RSC
- Apparent power flow through GSC
- Control system

- Electrical protection
- Electromechanical protection

10- Type 4 wind energy conversion system
- Full converter
- Control system
- Power flow
- Real power control
- Reactive power control
- Protection

11- Power quality and wind power
- Introduction
- Voltage variations
- Flicker
- Harmonics
- Transients: low Voltage Ride-Through (LVRT) capability of the different types of WTs
- Frequency

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.

Laboratory practices will be assessed and problems will be solved with the use of specific software packages.

ASSESSMENT SYSTEM

In the ordinary call, students will have to submit a report on the chosen project, present the results and make an oral final exam.
In the resit students must take a written examination , 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

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- 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
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- R Clark Small Wind, 1st Edition Planning and Building Successful Installation, Elsevier, 2013
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