Course guide
820156 - GEO - Wind Energy Generation

Last modified: 30/06/2023

Unit in charge: Barcelona East School of Engineering
Teaching unit: 709 - DEE - Department of Electrical Engineering.

Degree: BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Optional subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish, English

LECTURER

Coordinating lecturer: ÁNGEL SILOS SÁNCHEZ

Others: ÁNGEL SILOS SÁNCHEZ

PRIOR SKILLS

- Basic knowledge about generation and distribution of electric energy as well as applied knowledge of renewable energy.

REQUIREMENTS

- It is not necessary to have completed another previous subject.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEELE-25. Understand the applications of power electronics.
CEELE-28. Understand the applications of renewable energies.
CEENE-250. Knowledge of the principles of operation of electric power transmission and distribution systems.

TEACHING METHODOLOGY

-In the theory classes, the theoretical foundations of programmed materials will be exposed and developed. They consist of theoretical explanations complemented by activities to encourage students' participation, discussion, and critical analysis.
-In the classes, problems will arise and solve exercises related to the matters. Students should meet individually or in groups on these problems and deliver a report at the end of the course.
-At the laboratory, students will conduct laboratory practices as required and submit the relevant report with all practices along with appropriate calculations and critical considerations at the end of the course.
-A research report about a specific topic related to the subject will be done during the course with an oral presentation.
-During the classes, a technical project will be carried out in a group to apply the exposed knowledge in the course.

LEARNING OBJECTIVES OF THE SUBJECT

- Understand world wind generation market.
- Understand the different technologies of wind generation of electricity.
- Know how to determine the location of wind resources.
- Understand the different possibilities of control of wind turbines.
- Understand its operation in the power system.
- Know how to model, simulate the whole farm system.
- Learn to perform a pre-dimensioning of wind systems.

STUDY LOAD

Type	Hours	Percentage
Hours small group	15,0	10.00
Hours large group	45,0	30.00
Self study	90,0	60.00

Total learning time: 150 h

CONTENTS

1. General concepts

Description:
1.1 Overview of wind energy conversion systems
1.2 Wind energy technology
1.3 WECS configurations
1.4 Grid code
1.5 National and international wind generation market

Specific objectives:
- Acquire an overview of wind power generation.

Related activities:
- Related exercises and practice 1.

Full-or-part-time: 16h 40m
Theory classes: 3h
Laboratory classes: 2h
Self study : 11h 40m

2. The wind resource

Description:
2.1 General concepts
2.2 Variation in height and space
2.3 Variability of wind in time
2.4 Determination of gross energy yield
2.5 Assessment of resources
2.6 Wind measurements
2.7 Special offshore effects

Specific objectives:
- Define wind site resources taking account selected turbines.

Related activities:
- Related exercises and practices 2 and 3.

Full-or-part-time: 23h 20m
Theory classes: 3h
Laboratory classes: 4h
Self study : 16h 20m

3. Fundamentals of wind energy conversion system control

Description:
3.1 Wind turbine aerodynamics
3.2 Maximum power point tracking (MPPT) control
3.3 Wind turbine components

Specific objectives:
- Learn about aerodynamic control of the wind turbine.

Related activities:
- Related exercises and practices 4 and 5.

Full-or-part-time: 33h 20m
Theory classes: 6h
Practical classes: 4h
Self study : 23h 20m

4. Wind farm layout

Description:
4.1 Wind farm layout design
4.2 Electrical grid collector design
4.3 Wind farm connected to high voltage alternative current (HVAC)
4.4 Wind farm connected to high voltage direct current (HVDC)

Specific objectives:
- Understand the different layout designs and electrical infrastructure of a wind farm.

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

5. Grid Integration

Description:
5.1 Power system concepts
5.2 Wind power variability and limited predictability
5.3 Grid codes for Wind Turbines
5.4 Grid code requirements

Specific objectives:
- Understand network codes for wind farms.

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

6. Wind generators and modelling

Description:
6.1 Reference frame transformations
6.2 Induction generator models
6.3 Synchronous generators

Specific objectives:
- Understand synchronous and induction generator modeling.

Related activities:
- Practice 6.

Full-or-part-time: 16h 40m
Theory classes: 3h
Laboratory classes: 2h
Self study : 11h 40m

7. Power Converters in wind energy conversion systems

Description:
7.1 Two-level voltage source converters
7.2 Three-level neutral point clamped converters
7.3 Comparison 2-level and 3-level converters
7.4 Converter control

Specific objectives:
- Understand the differences between converter types.

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

8. Wind Energy Conversion System Configurations

Description:
8.1 Fixed speed WECS
8.2 Variable speed induction generator WECS
8.3 Variable speed synchronous generator WECS

Specific objectives:
- Understand different WECS systems and analyze future trends.

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

A. Annex IEC 61850

Description:
- IEC 61850. Communication and automation standard for the electrical sector.

Specific objectives:
- Understand scope of the IEC 61850 for the electrical sector and for the wind sector.

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

B. Other annexes

Description:
- Wind Turbine classification
- Maintenance
- HVDC vs HVAC
- Wind farms architectures.

Specific objectives:
- Include new interesting topics proposed by students.

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

GRADING SYSTEM

-Research report with oral presentation (25%)
-Exercise report (5%)
-Final exam (30%)
-Laboratory report (20%)
-Technical project (20%)
Note 1: It's mandatory to perform a laboratory report to pass this subject.
Note 2: It's mandatory to perform all parts of this subject to pass it.
Nota 3:There is no reassessment test.

EXAMINATION RULES.

-The written test is face-to-face and individual.
-The laboratory report is in a group, and the exercise report is individual.
-The research report with oral presentation is individual.
-The technical project is in a group.
-In exercise and laboratory reports will be assessed, where appropriate, the prior work with the presentation of results of each activity.

BIBLIOGRAPHY

Basic:
- Wu, B.. Power conversion and control of wind energy systems. Hoboken: Wiley-IEEE Press, 2011. ISBN 9780470593653.

Complementary:
- Ackerman, Thomas. Wind power in power systems [on line]. Second edition. Chichester, United Kingdom: John Wiley & Sons, 2012

[Consultation: 05/10/2020]. Available on: https://onlinelibrary.wiley.com/doi/book/10.1002/9781119941842. ISBN 0470855088.
- Lubosny, Zbigniew. Wind turbine operation in electric power systems : advanced modeling. Berlin [etc.]: Springer, 2003. ISBN 354040340X.
- Freris, L. L. Renewable energy in power systems. Chichester, U.K: John Wiley & Sons, 2008. ISBN 9780470017494.
- Heier, Siegfried. Grid integration of wind energy conversion systems. 2nd ed. Chichester [etc.]: John Wiley & Sons, cop. 2006. ISBN 0470868996.
- Teodorescu, Remus. Grid converters for photovoltaic and wind power systems [on line]. Chichester, West Sussex: John Wiley & Sons, 2011 [Consultation: 27/05/2020]. Available on: https://onlinelibrary.wiley.com/doi/book/10.1002/9780470667057. ISBN 9780470057513.
- Stiebler, Manfred. Wind energy systems for electric power generation [on line]. Berlin: Springer, cop. 2008 [Consultation: 27/05/2020]. Available on: http://dx.doi.org/10.1007/978-3-540-68765-8. ISBN 9783540687658.
- Hau, Erich. Wind turbines : fundamentals, technologies, application and economics [on line]. 2nd ed. Berlin [etc.]: Springer, 2006 [Consultation: 27/05/2020]. Available on: http://dx.doi.org/10.1007/3-540-29284-5. ISBN 9783540292845.
- Burton, Tony. Wind energy handbook [on line]. 2nd ed. Chichester [etc.]: John Wiley & Sons, cop. 2011 [Consultation: 05/10/2020]. Available on: https://onlinelibrary.wiley.com/doi/book/10.1002/9781119992714. ISBN 9781119992714.

RESOURCES

Other resources:
- Papers, documentation and web pages of interest which will be delivered during the course.