Guía docente
2400134 - 240MER41 - Integración de Energías Renovables en la Red Eléctrica

Última modificación: 13/05/2025

Unidad responsable: Escuela Técnica Superior de Ingeniería Industrial de Barcelona
Unidad que imparte: 709 - DEE - Departamento de Ingeniería Eléctrica.

Titulación: MÁSTER UNIVERSITARIO EN SISTEMAS Y ACCIONAMIENTOS ELÉCTRICOS (Plan 2021). (Asignatura optativa).
MÁSTER UNIVERSITARIO EN INGENIERÍA DE LAS ENERGÍAS RENOVABLES (Plan 2025). (Asignatura optativa).

Curso: 2025 **Créditos ECTS:** 5.0 **Idiomas:** Inglés

PROFESORADO

Profesorado responsable: Oriol Gomis-Bellmunt

Otros: Oriol Gomis-Bellmunt
Eduardo Prieto-Araujo
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Montserrat Montalà-Palau

CAPACIDADES PREVIAS

Basic electrical engineering
Electrical circuits analysis

REQUISITOS

Basic electrical engineering
Electrical circuits analysis

METODOLOGÍAS DOCENTES

* Presential
* Theory classes, Simulation practices, Project assignment
* 2 hours class / 1 hour additional for group work
* Lectures + discussions + problem solving

Students study documents at home
Students are assigned small project to develop in groups
Students work in small groups
Matlab/Python installation is required
The classes are organized as follows:
* Lectures
* Discussion on the studied materials
* Discussion on the evolution of the assignments
* Clarification of doubts
* Exercises and calculations

OBJETIVOS DE APRENDIZAJE DE LA ASIGNATURA

The course will focus on providing the knowledge and the tools needed to understand and analyze the interaction between renewable energies and power systems.

Specific objectives include covering the following topics:
- Analysis of power systems with a high penetration of renewables
- Grid integration of renewables
- Smart grids
- Grid codes
- Isolated and connected Microgrids
- HVDC Supergrids for offshore wind
- The role of energy storage and demand side management

HORAS TOTALES DE DEDICACIÓN DEL ESTUDIANTADO

Tipo	Horas	Porcentaje
Horas grupo grande	45,0	100.00

Dedicación total: 45 h

CONTENIDOS

Introduction and overview of renewable generation technology

Descripción:
The module provides an introduction to the field of renewable energies to the electrical power system. The main technologies, trends and challenges will be introduced.

Objetivos específicos:
To understand the classic and modern power systems
To understand the grid challenges associated to the energy transition
To understand the different technologies related to renewable generation and conventional generation

Dedicación: 18h
Grupo grande/Teoría: 9h
Aprendizaje autónomo: 9h

Modern power systems based on renewable generation

Descripción:
Modern power systems based on renewable generation will be studied focusing on renewable integration at different voltage levels. The different relevant challenges will be discussed and the technical solution will be explored to allow a massive integration of renewables while considering the economic and social constraints. Furthermore, the module will explore renewables integration under the Supergrid and Microgrid paradigms.
The Supergrid concept will be presented. It allows integration of large amounts of renewable (as offshore wind), also interconnecting different power system. HVDC transmission systems are introduced and analyzed. Some relevant example projects as Desertec, Medgrid, European Supergrid are presented. The microgrid concept will be also presented. It allows integration of different renewable energy sources combined with energy storage devices in isolated or grid connected grids. Different microgrid example will be discussed and analyzed.

Objetivos específicos:
To understand modern power systems based on renewables
To explore the supergrid and microgrid concepts
To apply the theory to a use case

Actividades vinculadas:
Course project: Project of planning a modern power system dominated by renewables

Dedicación: 36h
Grupo grande/Teoría: 18h
Aprendizaje autónomo: 18h

Grid support from renewable generation

Descripción:
The module introduces grid support from renewable energies, including frequency support, voltage support, black start, frid forming and power system stability support. The different relevant grid codes are presented. Additional support technologies as energy storage or FACTs (flexible AC transmission systems) are described. The different grid services required in modern power systems will be analyzed and discussed. The module will also discuss what controllers are needed to implement the services and some practical exercises will be conducted.

Objetivos específicos:
To understand how renewables can provide grid support in modern power systems
To design power systems with massive penetration of renewables
To conduct practical calculations of realistic problems

Actividades vinculadas:
Activity related to grid integration of renewable energy: Ramping control of solar PV plants using energy storage units. The assignment will be related to the sizing of energy storage systems to smooth the power injection of a large solar power plant considering the effect of clouds in power production.

Dedicación: 36h
Grupo grande/Teoría: 18h
Aprendizaje autónomo: 18h

SISTEMA DE CALIFICACIÓN

FINAL MARK = 0.5 FINAL EXAM + 0.5 PROJECT

FINAL EXAM (Written exam)
Multiple choice test (50 %)
Conceptual theoretical and practical questions (50 %)

PROJECT Course project & exercises
Project report & presentation (60 %)
Additional PROJECT questions in the exam (40 %)

NORMAS PARA LA REALIZACIÓN DE LAS PRUEBAS.

Exercises are included, but calculations will not be needed (only methodology)
Students cannot use any additional material in the exam. Only pen.

BIBLIOGRAFÍA

Básica:
- Carlos Collados-Rodríguez, Eduard Antolí-Gil, Enric Sánchez-Sánchez, Jaume Girona-Badia, Vinicius Albernaz Lacerda, Marc Cheah-Mañe, Eduardo Prieto-Araujo, Oriol Gomis-Bellmunt. "Definition of Scenarios for Modern Power Systems with a High Renewable Energy Share". Global Challenges - Wiley [en línea]. Disponible a: https://onlinelibrary.wiley.com/doi/full/10.1002/gch2.202200129.

Complementaria:
- Freris, L. L.. Renewable energy in power systems. Chichester, UK: John Wiley & Sons, 2008. ISBN 9780470017494.
- Jenkins, Nick. Embedded generation [en línea]. London: The Institution of Electrical Engineers, cop. 2000 [Consulta: 12/09/2025]. Disponible a: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=407962. ISBN 0852967748.
- Anaya-Lara, Olimpo. Wind energy generation : modelling and control [en línea]. Chichester, U.K.: John Wiley & Sons, 2009 [Consulta: 12/09/2025]. Disponible a: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=454292. ISBN 9780470714331.
- Van Hertem, Dirk; Gomis i Bellmunt, Oriol; Liang, Jun. HVDC grids for offshore and supergrid of the future [en línea]. Hoboken, New Jersey: IEEE/Wiley, cop. 2016 [Consulta: 12/09/2025]. Disponible a: https://onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/book/10.1002/9781119115243. ISBN 9781118859155.