Renewable Energy Grid Integration and Distributed Generation

Specialization Syllabus

Instituto Universitario de Investigación Mixto
circe
UniversidadZaragoza

Contents:

DISTRIBUTED GENERATION AND RENEWABLE ENERGY GRID INTEGRATION SPECIALIZATION

DISTRIBUTED GENERATION (2 ECTS)		
Syllabus		
1.A. Power System Operation		
- Electric grid introduction - Supply guarantee and power quality - Stability - Effects of renewable energy into the grid - Boundaries of the actual grid configuration - Consumption models and patterns. Demand Side Management		
1.B. Distributed Generation Definition		
- Integration in power systems - Distributed generation advantages and needs		
Learning outcomes		
Due to the different origins of the students, in this first subject basic theory and practical knowledge about the electric energy will be taught in order to unify their starting point and making it easier for them to apply the later concepts. Distribution, stability, power grid quality concepts will be revised as well as the effects of renewable energy into the grid. The concept of distributed generation is as well introduced.		
Module Coordinator	Mayte Villén Martinez	
Lecturers	Laura Giménez de Urtasun Miguel García-Gracia Mayte Villén Martinez Samuel Borroy Vicente Miguel Angel Cova Agustín Díaz Jose Mª Yusta Loyo Andrés Llombart	
Language	English	
ECTS credits	2	
Teaching format / class hours	12h 0 h 0 h 6 h	Lecture Laboratory Excursion Others...(Test, Oral presentation, Tutorials)
Student personal work	38h	

Assessment methods	Developed topic presentation
Literature	• “Power System Analysis” by John J. Grainger, William D. Stevenson.1995, McGraw-Hill Inc. • “Power System Analysis and design” by J. Duncan Glover, Mulukutla S. Sarma, and Thomas Overbye. 2008, Cengage Learning. • “Electrical Machines, Drives and Power System” by Theodore Wildi.2002, Prentice-Hall. • “Guide to Electrical Power Distribution Systems” by A.J. Pansini. 2005, The Fairmont Press Inc. • “Tecnología eléctrica” by M.Paz Comech, M. Garcia-Gracia. • "Análisis de circuitos eléctricos I” by A.A. Bayod; J.L. Bernal; J.A. Dominguez; M.A. García García; A. Llombart; J.M. Yusta. Colección Textos Docentes, vol. 58. Prensas Universitarias de Zaragoza.

GENERATION AND STORAGE TECHNOLOGIES (4.5 ECTS)	
Syllabus	
2.A. Wind Power	
- Wind power generation profiles - Wind power generation advantages and disadvantages - Wind power generation electric features	
2.B. Distributed Generation Definition	
- Photovoltaic and Thermo-solar power generation profiles - Photovoltaic and Thermo-solar power generation electric features - Diary/Monthly generation simulations and its comparison to a building consumption	
2.C. Biomass Power	
- General view	
2.D. Hydraulic Power	
- Hydroelectric centrals with asynchronous machine - Hydroelectric centrals with synchronous machine - Secondary regulation	
Mini-hydraulic central visit	
2.E. Hydrogen Technologies	
- State of the art (generation, transport and storage)	
Hydrogen applications and Walqa visit	
2.F. Power Storing	
- Battery types - Ultra capacitors based energy storage systems - Flywheel	
2.G. Electric Vehicles	
- EV interests. Random generation forecast corrections - EV needs according to users and grid exigencies - Dimension and security according to EV needs - Batteries and chargers - Standard UNE 61851. EV conductive system	
Learning outcomes	
In this subject some of the basic aspects of renewable energy generation are shown. Besides storage technologies will be explained for considering their development essential for the success of distributed generation.	
Module Coordinator	Adrián Alonso Herranz

Lecturers	Jesús Sallán Fernando Sebastián Angel Bayod Emilio Puértolas Joaquin Chacón Jesús Simón Antonio Usón Jesús Letosa Adrián Alonso Estanis Oyarbide José Sanz Diego López	
Language	English	
ECTS credits	4.5	
Teaching format / class hours	27h 2 h 7 h 9 h	Lecture Laboratory Excursion Others...(Test, Oral presentation, Tutorials)
Student personal work	81h	
Assessment methods	Exam Developed topic presentation	
Literature	• “Energy Storage for Power Systems” by A. Ter-Gazarian. IEE Energy, No 6. • “Integration of Alternative Sources of Energy” by Felix A. Farret and M. Godoy Simoes. 2006, John Wiley and Sons. • “Distributed Generation” by Ann-Marie Borbely, Jan F. Kreider. 2001, CRC Press.	

CONTROL TECHNIQUES AND RENEWABLE ENERGY INTEGRATION SYSTEMS (5.5 ECTS)

Syllabus

3.A. AC/DC Drives Control

- Introduction to basic analysis and operation techniques on power electronic systems.
- Basic commutation cell
- Functional analysis of power converters main topologies
- Power conversion schemes between electric machines and the grid
- Power systems control using power converters
- High power electronic converters. Tendencies, topologies and basic functional principles
- Multilevel converter with 3 stages
- Electronic conversion systems application to renewable energy generation systems. Basic schemes and functional advantages. Wind Power and Photovoltaic Power applications.

3.B. Predictive direct power control of systems connected into the grid

3.C. Technological aspects of power electronic systems connection to the grid

- PLL
- Sampling effect, commutation frequency, etc… Modulation types
- Dimensioning LC filters
- Harmonic cancellation by modulation

3.D. Active Network Devices, Control and FACTS Technology

- Theory and operation principle of FACTS
- Implementation and FACTS technologies (Series / Shunt compensation)
- Talk from “Wind to Power System” (Carlos III University)

3.E. Micro-Grids

- Resources evaluation and needs
- Dimensioning integration systems
- Optimizing integration systems
- Integration systems control
- Cases of study: multi-generation buildings

Possible visit to tri-generation central

Learning outcomes

To study the power electronic basic concepts as a tool for the process of electric power, this will have high efficiency by means of electronic states. To know the conversers and electronic devices developed for the integration of renewable energies.

Module Coordinator	Nabil El Halabi Fares	
Lecturers	Gustavo Quiñones Oscar Alonso Miguel de la Torre Rodriguez Jorge Ribot Vallejo Pablo Martín Muñoz Estanis Oyarbide Nabil El Halabi Adrián Alonso Herranz Andrés Llombart Javier Uche	
Language	English	
ECTS credits	5.5	
Teaching format / class hours	36 h 8 h 2 h 9 h	Lecture Laboratory Excursion Others...(Test, Oral presentation, Tutorials)
Student personal work	99 h	
Assessment methods	Exam Subject's work Developed topic presentation	
Literature	• "Understanding FACTS: Concepts and Technology of Flexible AC. Transmission Systems" Wiley, by N.G. Hingorani; L. Gyugyi. 1999, John Wiley and Sons. • "FACTS, Modelling and Simulation in Power Networks" by E. Acha; C.R. Fuerte-Esquivel; H. Ambriz-Perez; C. Angeles-Camacho. 2004, John Wiley and Sons. • "Power Electronics, Converters, Applications and Design" by N. Mohan; T.M. Undeland; W.P. Robbins. 1995, John Wiley and Sons.	

POWER GRID ANALYSIS AND STUDIES (6 ECTS)

Syllabus

4.A. Electric Systems Modelling

- Modelling and simulation of electric systems introduction. Simulation grid studies and used tools. Unit systems.
- Electric systems modelling for permanent regime studies
- Steady state simulation studies. Load flow
- Line, cable, transformer, generator and load models.
- Sequence grids, three phase short-circuit
- Transient regime electric systems modelling. Line modelling
- Transient regime electric systems modelling. Transformer
- Substation structure
- Generation systems modelling// microgrid modelling

4.B. Power Supply Quality

- Background and problems of the lack of electric supply quality
- Frequency variators
- Slow voltage variations
- Flicker voltage fluctuations
- Voltage gaps and brief voltage cuts
- Voltage boosts
- Harmonic distortion
- Voltage unbalances

Wind Power Central or MEGHA visit

4.C. Optimization and Grid Planning

- "A Benders Decomposition and Fuzzy Multicriteria Approach for Distribution Networks Remuneration Considering DG"
- Integral planning of primary-secondary distribution systems using mixed integer linear programming
- A probabilistic methodology for distribution substation location
- A linear programming methodology for the optimization of electric power-generation schemes

Learning outcomes

This subject will present the different studies to undertake in electric grids to assure a correct planning and operation.
The modelling of electric grid elements will be shown in a general way, and in a more specific way for each kind of study, that could be for permanent, dynamic or transitional regimes.
The features for power supply quality will be exposed, as well as the measure and verification tools used to verify the quality levels to apply in the grid studies.

Module Coordinator	Mª Paz Comech Moreno

Lecturers	Ana Morales Mª Paz Comech Moreno Laura Giménez de Urtasun Nabil El Halabi Adrian Alonso Miguel García-Gracia Mayte Villén Martinez Miguel Angel Cova Jorge Bruna Carlos Izquierdo Armesto Sergio Martínez Villanueva Hussein Khodr	
Language	English	
ECTS credits	6	
Teaching format / class hours	28 h 19 h 2 h 9 h	Lecture Laboratory Excursion Others...(Test, Oral presentation, Tutorials)
Student personal work	110 h	
Assessment methods	Exam Subject's work Developed topic presentation	
Literature	• "Power System Analysis" by John J. Grainger, William D. Stevenson.1995, McGraw-Hill Inc. • "Power Systems Modelling and Fault Analysis: Theory and Practice" by N.D. Tleis. 2008, Elsevier Ltd.	

SMART GRIDS (4.5 ECTS)	
Syllabus	
5.A. Smart Grids Programming	
- Virtual Power Producer - Intelligent reconfiguration including SCADA distributed generators	
5.B. Protective Devices	
- Introduction to protections + Overcurrent, Distance, Differential - Protection coordination - Smart Grids: From the System Operator point of view (Demand Management, Electric Vehicle, Storage) - Renewable energies protection	
REE control centre and RREE centre visit	
5.C. Case of Study: Distributed Generation Protection	
- Distributed grids protection - Problems in distributed grids - Solutions	
5.D. SMART GRIDS	
- IEC 61850 - Supply guarantee automatisms - Control devices. IEDs - Measurement and control communications (PLC, wireless…)	
Malaga experience visit	
Learning outcomes	
To give the student smart-grids programming and protecting knowledge. The present experiences will be shown as well as technologies and devices being used.	
Module Coordinator	Samuel Borroy Vicente
Lecturers	Hussein Khodr Samuel Borroy Vicente Laura Giménez de Urtasun Miguel Ordiales Botija Mayte Villén Martinez Samuel Borroy Vicente Maciej Goraj Mª Paz Comech Moreno Felipe Alvares-Cuevas Figuerola Laura Corbeira Graell
Language	English
ECTS credits	4.5

Teaching format / class hours	25 h 3 h 8 h 9 h	Lecture Laboratory Excursion Others...(Test, Oral presentation, Tutorials)
Student personal work	81 h	
Assessment methods	Exam Subject's work Developed topic presentation	
Literature	• "Power Systems Protection, Power Quality, Substation Automation" 1994, IDC TechBooks. • "IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems" 2001, IEEE Inc. • "Protective Relaying of Power Systems Using Mathematical Morphology" by Q.H. Wu; Z. Lu; T.Y. Ji. 2009, Springer Inc. • "The Art and Science of Protective Relaying" by C.R. Mason. GE Inc. • "Telecommunication—Handbooks, manuals, etc" by P.I. Morreale, K. Terplan. 2000, CRC Press.	

<table>
<tr><th colspan="3">STANDARDS AND ELECTRIC MARKETS (2.5 ECTS)</th></tr>
<tr><td colspan="3">Syllabus</td></tr>
<tr><td colspan="3">6.A. Electric Market</td></tr>
<tr><td colspan="3">- The electric sector: structures and models
- Economics in distributed generation. Remuneration
- Regulation comparison with other international electric markets experiences
- Regulation of the electric sector impact on distributed generation
- New activities regulation proposals</td></tr>
<tr><td colspan="3">6.B. Standards</td></tr>
<tr><td colspan="3">- State of the art
- Power supply quality generic standards
- Renewable energies specific standards</td></tr>
<tr><td colspan="3">Learning outcomes</td></tr>
<tr><td colspan="3">To know the different law and economic regulations in distributed generation for the liberalized markets, and to identify the boundaries and opportunities in those fields.</td></tr>
<tr><td>Module Coordinator</td><td colspan="2">José Mª Yusta Loyo</td></tr>
<tr><td>Lecturers</td><td colspan="2">Jose Mª Yusta Loyo
Julio Melero
José Luis Fernández González</td></tr>
<tr><td>Language</td><td colspan="2">English</td></tr>
<tr><td>ECTS credits</td><td colspan="2">2.5</td></tr>
<tr><td>Teaching format / class hours</td><td>19 h
0 h
0 h
6 h</td><td>Lecture
Laboratory
Excursion
Others...(Test, Oral presentation, Tutorials)</td></tr>
<tr><td>Student personal work</td><td colspan="2">45 h</td></tr>
<tr><td>Assessment methods</td><td colspan="2">Developed topic presentation</td></tr>
<tr><td>Literature</td><td colspan="2">• “The Power to Choose: Demand Response in Liberalised Electricity Markets” 2003, OECD/IEA.</td></tr>
</table>

PROJECT (5 ECTS)	
Learning outcomes	
Students develop a project on any subject, related to any of the modules in the specialization. The issue is approved by a professor who directs and guides the student. Any module coordinator can be director of the project. For evaluation, the student submits a report of the work done.	
Module Coordinator	Miguel García Gracia
Language	English
ECTS credits	5
Student personal work	140 h
Assessment methods	Developed work report