Module Handbook Grid Integration - Zaragoza

Fakultät 5: Mathematik und Naturwissenschaften Institut für Physik *Subject:* European Master in Renewable Energy Summer Term 2017	*Category:* - Master Module *Degree award:* - Master
Emphases: -	*Sections:* -
Module reference number/Title: **pre371 - Distributed Generation**	
Duration: 1 semester *Cycle:* once a year *Type of module:* mandatory *Level:* MM (master module) *This module should be taken in* 2nd semester	*Type of program:* - Lecture, Laboratory, Excursion *Language:* English *Attainable credit points:* 2,00 CP *Workload:* 50 hours *Required attendance:* 18 hours
Person responsible for the programme: Mª Paz Comech Moreno	*Person responsible for this module:* Mayte Villén Martínez
Alternative person(s) responsible for this module: A. Alonso, E. Martínez, M.G. Cañete, M.P. Comech, S. Borroy, L. Giménez	*Examiner(s):* All listed persons
Objective of the module / skills: By the end of this module, the student will - be able to manage theoretical aspects related to power distribution, stability and quality The students will: - become familiar with the basic theory and practical knowledge about the electric energy - get basic knowledge on supply guarantee and power quality topics - get basic knowledge on stability issues - know the main effects of the introduction of Renewable Energies into the electric grid - become familiar with the substations principles - get knowledge about the concept of distributed generation and its implications - will be able to demonstrate in-depth knowledge of Power Systems operations and Distributed Generation integration in existing grids - be able to work effectively as professionals and as team members in order to solve technical problems - be able to demonstrate their abilities to communicate effectively in multinational teams	
Content of the module:	

- Introduction to electric grid
- Security of supply and grid quality
- Stability
- Electric circuits analysis
- Renewable energy impact on the grid
- Laboratory classes (three-phase systems)
- Laboratory classes (reactive energy compensation)
- Models or patterns of consumption. Response / Demand Management
- Basic concepts of power electronics

Suggested reading:

John J. Grainger, William D. Stevenson: Power System Analysis. McGraw-Hill Inc, 1995.

J. Duncan Glover, Mulukutla S. Sarma, and Thomas Overbye: Power System Analysis and design. Cengage Learning, 2008.

Theodore Wildi: Electrical Machines, Drives and Power System. Prentice-Hall, 2002.

A.J. Pansini: Guide to Electrical Power Distribution Systems. The Fairmont Press Inc, 2005.

M. Paz Comech, M. Garcia-Gracia: Tecnología eléctrica.

A.A. Bayod; J.L. Bernal; J.A. Dominguez; M.A. García García; A. Llombart; J.M. Yusta: Análisis de circuitos eléctricos I. Colección Textos Docentes, vol. 58. Prensas Universitarias de Zaragoza.

Comments:

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Weblink:

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Prerequisites for admission:

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Helpful previous knowledge:

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Associated with the module(s):

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Maximum number of students / selection criteria:

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Types of examinations:

Written exam (95%): 2 hours

Subject's work (5%): approx. 4 hours (Subject's work refers to the different assignments that students are asked to finish after a preliminary session during the lessons)

Examination periods:

After end of lectures of module

Registration procedure:

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Fakultät 5: Mathematik und Naturwissenschaften Institut für Physik *Subject:* European Master in Renewable Energy Summer Term 2017	*Category:* - Master Module *Degree award:* - Master
Emphases: -	*Sections:* -

Module reference number/Title:

pre372 - Generation and Storing Technologies

Duration: 1 semester *Cycle:* once a year *Type of module:* mandatory *Level:* MM (master module) *This module should be taken in* 2nd semester	*Type of program:* - Lecture, Laboratory, Excursion, Tutorial *Language:* English *Attainable credit points:* 4,50 CP *Workload:* 112,5 hours *Required attendance:* 45 hours
Person responsible for the programme: Mª Paz Comech Moreno	*Person responsible for this module:* Adrián Alonso Herranz
Alternative person(s) responsible for this module: M. Villén, E. Martínez, M.G. Cañete, M.P. Comech, S.Borroy, L. Giménez	*Examiner(s):* All listed persons

Objective of the module / skills:

By the end of this subject, students should be able to display a clear understanding of the state of the art of RE power generation technologies, the theoretical aspects of storage technologies and the impact of electric vehicles in the electric grid.

The student will get a suitable knowledge about the following topics:

- Distributed Generation main concepts
- New generation technologies
- Wind power generation
- Biomass power
- Hydraulic Power
- Storage
- Electric vehicle regarding grid integration

Engineering analysis:

Graduates will be able to demonstrate a clear understanding of the state of the art of RE power generation technologies and related aspects as storage or impact in the electric grid.

Transferable skills:

Graduates will be able to work effectively as a professional and as team member in the resolution of technical problems. Also, graduates will demonstrate their abilities to communicate effectively in multinational groups.

Content of the module:

1. Basics aspects of Distributed Generation
- Challenges of the SEP operation due to the high penetration of RES
- Challenges and technological trends in the renewable energy grid integration
- Advantages and disadvantages of distributed generation
- Optimization of the integration of distributed generation
- Marine and offshore technology generation and market
- Visit to PV system facility
- Applications of hydrogen and visit to the Hydrogen Foundation
- Visit to a hydroelectric plant
- Electric Vehicle
- Wind prediction techniques

2. Storage
- State of the art storage
- Batteries
- Flywheel
- Storage systems based on ultra-capacitors

Suggested reading:

A. Ter-Gazarian: Energy Storage for Power Systems. IEE Energy, No 6.

Felix A. Farret and M. Godoy Simoes: Integration of Alternative Sources of Energy. John Wiley and Sons, 2006.

Ann-Marie Borbely, Jan F. Kreider: Distributed Generation. CRC Press, 2001.

Comments:

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Weblink:

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Prerequisites for admission:

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Helpful previous knowledge:

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Associated with the module(s):

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Maximum number of students / selection criteria:

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Types of examinations:

Written exam (42.5%): 2 hours

Subject's work (7.5%): approx. 4 hours (Subject's work refers to the different assignments that students are asked to finish after a preliminary session during the lessons)

Presentation (50%): 20 minutes (developed topic)

Examination periods:

After end of lectures of module

Registration procedure:

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Fakultät 5: Mathematik und Naturwissenschaften Institut für Physik *Subject:* European Master in Renewable Energy Summer Term 2017	*Category:* - Master Module *Degree award:* - Master
Emphases: -	*Sections:* -

Module reference number/Title:

pre373 - Control Techniques and Renewable Energy Integration Systems

Duration: 1 semester *Cycle:* once a year *Type of module:* mandatory *Level:* MM (master module) *This module should be taken in* 2nd semester	*Type of program:* - Lecture, Laboratory, Excursion, Tutorials *Language:* English *Attainable credit points:* 5,50 CP *Workload:* 137,5 hours *Required attendance:* 55 hours
Person responsible for the programme: Mª Paz Comech Moreno	*Person responsible for this module:* Eduardo Martinez Carrasco
Alternative person(s) responsible for this module: M. Villén, A. Alonso, M.G. Cañete, M.P. Comech, S.Borroy, L. Giménez	*Examiner(s):* All listed persons

Objective of the module / skills:

By the end of this module, students should be able to manage the theoretical and practical aspects related to power electronics, with an emphasis in the analysis of the operation of specific devices used to integrate RE. They should also be able to evaluate the requirements, design and optimise Micro Grids.

At the completion of this module, the student will:

- Become familiar with the AC/DC Drives control systems (multilevel converters, PWM, etc…)
- Get basic knowledge on the technological aspects of power electronic systems connection
- Get knowledge about reactive power compensation
- Be introduced to FACTS Technology

Engineering analysis:

Graduates will be able to formulate and solve engineering problems related to the control of power systems connected to the grid. Also, the will be able to design and optimise Micro Grids.

Investigations:

Graduates will be able to evaluate the requirements to implement Micro Grids.

Transferable skills:

Graduates will be able to work effectively as professionals and as team members to solve technical problems related to the integration of RE in electric grids. Also, graduates will demonstrate their abilities to communicate effectively in multinational teams.

Content of the module:

1. Control of AC/DC drives
- Necessity of power electronics: solar and wind generation, storage, dip and reactive power compensation, DC transport…
- Modelling and simulation of power electronics systems
- Conversion DC/DC (Solar): topology, operation and current control
- Vectorial modelling of three phase systems
- Control of permanent magnets wind turbines
- Conversion DC/AC three phase
- Control of active and reactive power of three phase systems connected to grid
- Dip and interruptions compensation: DVR
- Characterization techniques: harmonics, THD, power factor…
- Overview of other power systems

2. Active network devices and control
- Control system for small wind turbines
- Power inverter design
- Microgrids
- Theory and operation principles of FACTS
- FACTS implementation and technology (Series / Shunt compensation)
- Applications and simulation of power electronics systems using PSCAD/EMTDC
- Modelling of thyristor-based static Var compensator
- Modelling of GTO-Based STATCOM -Modelling of VSC-Based HVD link
- Modelling and performance of SSCC in wind energy application

Suggested reading:

N.G. Hingorani; L. Gyugyi: Understanding FACTS: Concepts and Technology of Flexible AC. Transmission Systems. John Wiley and Sons, 1999.

E. Acha; C.R. Fuerte-Esquivel; H. Ambriz-Perez; C. Angeles-Camacho: FACTS, Modelling and Simulation in Power Networks. John Wiley and Sons, 2004.

N. Mohan; T.M. Undeland; W.P. Robbins: Power Electronics, Converters, Applications and Design. John Wiley and Sons, 1995.

Muhammad H. Rashid: Power Electronics Handbook. Academic Press, 2001.

Remus Teodorescu, Marco Liserre, Pedro Rodriguez: Grid Converters for Photovoltaic and Wind Power Systems. IEEE- Wiley and Sons Publications, 2011.

Comments:

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Weblink:

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Prerequisites for admission:

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Helpful previous knowledge:

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Associated with the module(s):

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Maximum number of students / selection criteria:

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Types of examinations:

Written exam (40%): 2 hours

Subject's work (20%): approx. 8 hours (Subject's work refers to the different assignments that students are asked to finish after a preliminary session during the lessons)

Presentation (40%): 20 minutes (developed topic)

Examination periods:

After end of lectures of module

Registration procedure:

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Fakultät 5: Mathematik und Naturwissenschaften Institut für Physik *Subject:* European Master in Renewable Energy Summer Term 2017	*Category:* - Master Module *Degree award:* - Master
Emphases: -	*Sections:* -

Module reference number/Title:

pre374 - Power Grid Analysis and Studies

Duration: 1 semester *Cycle:* once a year *Type of module:* mandatory *Level:* MM (master module) *This module should be taken in* 2nd semester	*Type of program:* - Lecture, Laboratory, Excursion, Tutorials *Language:* English *Attainable credit points:* 6,00 CP *Workload:* 150 hours *Required attendance:* 58 hours
Person responsible for the programme: Mª Paz Comech Moreno	*Person responsible for this module:* Mª Paz Comech Moreno
Alternative person(s) responsible for this module: M. Villén, A. Alonso, E. Martínez, M.G. Cañete, S.Borroy, L. Giménez	*Examiner(s):* All listed persons

Objective of the module / skills:

By the end of this module students should be able to acquire relevant data to evaluate grid power quality, to model permanent and dynamic transient regimes of electric grid elements and to plan and optimise grid design.

Specifically, the student will

- be able to perform different studies (permanent, dynamic or transitional regimes) to undertake in electric grids to ensure correct planning and operation
- get basic knowledge on grid modelling (static and dynamic)
- be able to perform stability studies
- get to know different aspects about power supply quality
- be able to perform an optimal sizing of renewable energies installations

Engineering analysis:

Graduates will be able to formulate and solve engineering problems related to Power Supply Quality.

Investigations:

Graduates will be able to acquire relevant data to evaluate grid power quality.

Engineering design:

Graduates will be able to model permanent and dynamic transient regimes of electric grid elements, also to plan and optimise grid design.

Transferable skills:

Graduates will be able to work effectively as a professional and as team member in the resolution of technical problems related to integration of RE in electric grids. Also, graduates will demonstrate their abilities to communicate effectively in multinational groups.

Content of the module:

1. Electric system modelling
- Introduction to the modelling and simulation of electric systems
- Per unit system
- Permanent regime simulation studies: load flows, short-circuits, sequence networks
- Transient regime modelling: lines, transformer, SEP stability, generation
- Modelado de sistemas eléctricos en régimen transitorio.
- RE integration analysis

2. Quality of supply
- Wind and solar farms verification procedures
- Grid Codes and dynamic models for different wind turbines
- Variable frequency drive
- Slow voltage variations
- Voltage fluctuations Flicker
- Voids voltage and short cuts
- Voltage pulses
- Harmonic distortion
- Voltage Imbalances
- Network quality and renewable energy
- Power quality analysers

Suggested reading:

John J. Grainger, William D. Stevenson: Power System Analysis. McGraw-Hill Inc, 1995.

N.D. Tleis: Power Systems Modelling and Fault Analysis: Theory and Practice. Elsevier Ltd, 2008.

Comments:

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Weblink:

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Prerequisites for admission:

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Helpful previous knowledge:

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Associated with the module(s):

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Maximum number of students / selection criteria:

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Types of examinations:

Written exam (50%): 2 hours

Subject's work (10%): approx. 8 hours (Subject's work refers to the different assignments that students are asked to finish after a preliminary session during the lessons)

Presentation (40%): 20 minutes (developed topic)

Examination periods:

After end of lectures of module

Registration procedure: -

Fakultät 5: Mathematik und Naturwissenschaften Institut für Physik *Subject:* European Master in Renewable Energy Summer Term 2017	*Category:* - Master Module *Degree award:* - Master
Emphases: -	*Sections:* -

Module reference number/Title:

pre375 - Smart Grids

Duration: 1 semester *Cycle:* once a year *Type of module:* mandatory *Level:* MM (master module) *This module should be taken in* 2nd semester	*Type of program:* - Lecture, Laboratory, Excursion, Tutorials *Language:* English *Attainable credit points:* 4,50 CP *Workload:* 112,5 hours *Required attendance:* 45 hours
Person responsible for the programme: Mª Paz Comech Moreno	*Person responsible for this module:* Samuel Borroy Vicente
Alternative person(s) responsible for this module: M. Villén, A. Alonso, E. Martínez, M.G. Cañete, M.P. Comech, L. Giménez	*Examiner(s):* All listed persons

Objective of the module / skills:

By the end of this module, students should be able to program and protect smart grids.

Student will get a suitable knowledge on:

- smart grid concept and development
- protection system in electrical power systems
- telecommunication infrastructure in smart grids

Engineering design:

Graduates will be able to design engineering solutions to the challenge of programming smart-grids. They will be able to do the complex task of coordinating protective devices for RE, integrate mini and micro generation in distribution grids or plan and optimise primary-secondary distribution systems.

Transferable skills:

Graduates will be able to work effectively as a professional and as team member in the resolution of technical problems related to integration of RE in electric grids. Also, graduates will demonstrate their abilities to communicate effectively in multinational groups.

Content of the module:

1. Programming of intelligent networks
   - Smart Grids from the point of view of the network operator (Demand Management, Electric Vehicle, Storage...)

- Operation and network planning with quality criteria distribution
- Optimization Techniques
- Practice microgrids

2. Protections
- Introduction
- Overcurrent protection
- Distance protection
- Differential protection
- Protection coordination
- Problematic of distributed generation

3. Smart Grids
- IEC 61850 communications
- Visit to Red Eléctrica de España control center
- Visit to UFD facilities: Smart grids projects
- PLC communications: Malaga Smart city experience
- Visit to ERZ control center: smart meters

Suggested reading:

Power Systems Protection, Power Quality, Substation Automation. IDC TechBooks, 1994.

IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems. IEEE Inc, 2001.

Q.H. Wu; Z. Lu; T.Y. Ji: Protective Relaying of Power Systems Using Math. Morphology. Springer, 2009.

C.R. Mason: The Art and Science of Protective Relaying. GE Inc.

P.I. Morreale, K. Terplan: Telecommunication—Handbooks, manuals, etc. CRC Press, 2000.

Comments:

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Weblink:

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Prerequisites for admission:

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Helpful previous knowledge:

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Associated with the module(s):

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Maximum number of students / selection criteria:

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Types of examinations:

Written exam (50%): 2 hours

Subject's work (10%): approx. 4 hours (Subject's work refers to the different assignments that students are asked to finish after a preliminary session during the lessons)

Presentation (40%): 20 minutes (developed topic)

Examination periods:

After end of lectures of module

Registration procedure:

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Fakultät 5: Mathematik und Naturwissenschaften Institut für Physik *Subject:* European Master in Renewable Energy Summer Term 2017	*Category:* - Master Module *Degree award:* - Master
Emphases: -	*Sections:* -

Module reference number/Title:

pre376 - Standards and Electric Markets

Duration: 1 semester *Cycle:* once a year *Type of module:* mandatory *Level:* MM (master module) *This module should be taken in* 2nd semester	*Type of program:* - Lecture, Laboratory, Excursion, Tutorials *Language:* English *Attainable credit points:* 2,50 CP *Workload:* 62,5 hours *Required attendance:* 25 hours
Person responsible for the programme: Mª Paz Comech Moreno	*Person responsible for this module:* Laura Giménez de Urtasun
Alternative person(s) responsible for this module: M. Villén, A. Alonso, E. Martínez, M.G. Cañete, M.P. Comech, S. Borroy	*Examiner(s):* All listed persons

Objective of the module / skills:

By the end of this module, students should be able to display a clear understanding of the different laws and economic regulations ruling distributed generation in liberalised electric markets. Also, they should be able to identify boundaries and opportunities in those markets. At the completion of this module, the student will:

- become familiar with the basic rules of electric markets
- get know the standards for RE
- know the smart grid installations from the economical point of view

Engineering practice:

Graduates will possess a comprehensive understanding of the structure and regulations of local and international electric markets. The economics of distributed generation systems. The state of the art in standards and regulations ruling distributed generation in liberalised electric markets.

Transferable skills:

Graduates will be able to work effectively as a professional and team member in the resolution of technical problems related to integration of RE in electric grids. Also, graduates will demonstrate their abilities to communicate effectively with the engineering community in national and international contexts. They are able to demonstrate awareness of the legal issues and responsibilities of the engineering practice.

Content of the module:

- The electricity sector: structures and models
- Cost-benefit analysis of investment in RES
- Calculation of tariffs considering quality costs
- Socio-economic impact of Smart Grids
- Impact of high penetration of RES in the electricity market
- Specific regulations for renewable energy

Suggested reading:

The Power to Choose: Demand Response in Liberalised Electricity Markets. OECD/IEA, 2003.

Comments:

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Weblink:

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Prerequisites for admission:

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Helpful previous knowledge:

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Associated with the module(s):

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Maximum number of students / selection criteria:

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Types of examinations:

Written exam (50%): 2 hours

Presentation (50%): 20 minutes (developed topic)

Examination periods:

After end of lectures of module

Registration procedure:

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Fakultät 5: Mathematik und Naturwissenschaften Institut für Physik *Subject:* European Master in Renewable Energy Summer Term 2017	*Category:* - Master Module *Degree award:* - Master
Emphases: -	*Sections:* -

Module reference number/Title:

pre377 - Project

Duration: 1 semester *Cycle:* once a year *Type of module:* mandatory *Level:* MM (master module) *This module should be taken in* 2nd semester	*Type of program:* - Self-study *Language:* English *Attainable credit points:* 5,00 CP *Workload:* 125 hours *Required attendance:* -
Person responsible for the programme: Mª Paz Comech Moreno	*Person responsible for this module:* Mª Paz Comech Moreno
Alternative person(s) responsible for this module: M. Villén, A. Alonso, E. Martínez, M.G. Cañete, S. Borroy, L. Giménez	*Examiner(s):* All listed persons

Objective of the module / skills:

Investigations:

Graduates will be able to search and organise the required information for the report.

Transferable skills:

To evaluate students learning process through the development of a subject related to any of the modules in the specialization. Graduates will demonstrate their ability to investigate and recognise the need for lifelong learning.

Content of the module:

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.

Suggested reading:

Recommended literature of other modules

Comments: - *Weblink:*	*Helpful previous knowledge:* - *Associated with the module(s):*

- *Prerequisites for admission:* -	-
Maximum number of students / selection criteria: - *Types of examinations:* Written report *Examination periods:* After end of modules *Registration procedure:* -	