Course 2014-2015

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Introduction

Next academic year 2014-2015 the fifth edition of the Specialisation in “Renewable energy grid integration and distributed generation” will be taught by the University of Zaragoza, promoted by CIRCE. This course can be found as a specialisation of the European master offered by EUREC (European Association of Renewable Energy Research Centres) given by a consortium of European universities.

The course is given entirely in English, and it is divided in 6 subjects plus a compulsory project related to the specialisation, which in sum account 30 credits.

Its main objective is to offer a complete education, not just in new renewable generation technologies, but also in the smart grids complex world, with concepts like grid stability, grids quality, and supply guarantee; in present problems and solutions for renewable energy integration into the grid; and in electric markets, laws and standardization.

The contents of the course are highly technical, and the focus is practical, including the direct participation of facilities and other entities involved in the course topics.

The technology development in renewable energy and storage systems will suppose a revolution compared to the present electric system, losing some of the present dependency on big far-from-consumption- points centrals, that means huge maintenance costs and losses related to far-distances electricity transportation, beside the required voltage transformation. Next-to-consumption-points generation should help to improve the perception of quality electricity service by consumers. The importance of this quality service was already expressed in the Spanish laws in RD 1955/2000 the 1st of December, as it has been done all around Europe. This law regulates transport activities, distribution and commercialization, supply and installation authorization procedures.

Another distributed networks advantage is that it will enable to take into account each territory specific features, making it easier to optimise the system and to improve its efficiency, increasing the grid’s security, in the way that a failure in a generator will not have disastrous effects on the global system, and could be assumed faster.

Distributed generation systems feasibility needs a smart grid with continuous information about its installations available, allowing to solve possible problems affecting the optimal generation point. This smart grid should contribute with reliability, an automatic fault clearing system, energy management and a system to fix tariffs on electricity in time.

From the point of view of design, the smart grid requires the automation and communication technological development in order to incorporate distributed generation and storage into the grid. The complexity in the secondary distribution grid will increase, opening new paths for research and industrial development and innovation, which once the technology is controlled, will have worldwide expansion opportunities.
The course has the aim of encouraging the spread of technologies for distributed grids and the integration of renewable energies in our borders, making special effort in knowledge transfer between enterprises and researchers, and contributing to a sustainable development from the environmental, economical and social point of view.

In order to achieve our goals a large sum of companies and institutions support this initiative that is expected to stay close to reality and needs of our community. From the University of Zaragoza, the achievement of these goals has been seen as possible and it is starting from the beginning: professional training in the area.

A deep knowledge in distributed generation and renewable energies integration technology for its use in the energy sector is seen as a general goal in the course.

**Specific objectives**

After the completion of the course our students are expected to acquire a wide vision of the electric grid and the following knowledge and skills:

- Development of projects and studies for installations feasibility or renewable generation integration into the present grid and the future distributed generation grid.

- Knowledge of the potential uses that electronic and communication applications bring to distributed generation. Analyse of development possibilities in global and local scale.

- Regulations in renewable energies and distributed generation and how to apply laws and standards referred to the grid connexion.

- Apply and develop R&D&i projects and/or make investments in this sector, knowing the main enterprises, working groups and associations to collaborate with.
Methodology

Teaching will be based on lectures, laboratories, conferences, tutorials and visits given through all the subjects.

Sessions will be scheduled Monday to Thursday afternoon and Friday morning. Each session will have an approximate duration of 4 hours. The students will be provided with all necessary teaching materials.

Part of the course will be supported by practical training that will be given in the computer laboratories, combining the above explained theory with computer simulations and programming.

Practical training:

AC/DC Drives Control (4h)
- Electronic conversion systems application to renewable energy generation systems
- Basic schemes and functional advantages
- Wind Power and Photovoltaic Power applications

Applications and power system simulation using PSCAD/EMTDC (3h)
- Modelling of thyristor-based static Var compensator
- Modelling of GTO-Based
- Modelling of VSC
- Based HVDC Link
- Modelling and performance of SSCC in wind energy application

Electric Systems Modelling (21h)
- Electric systems modelling for simulation in dynamic regime
- Transient regime simulation studies

Micro Grids (6h)
- Communication
- Load control
- Generation control

Students will have access to the computer laboratories at any the time the laboratory room is free of any course. So they will be able to develop their tasks with special ICT facilities that will be installed there.

Other laboratories that students will visit and use, under supervision, can be seen in the following pictures:

Renewable Energies Integration Laboratory

Applications and power system simulation using PSCAD/EMTDC (3h)
- Modelling of thyristor-based static Var compensator
- Modelling of GTO-Based
- Modelling of VSC
- Based HVDC Link
- Modelling and performance of SSCC in wind energy application

Electric Systems Modelling (21h)
- Electric systems modelling for steady state regime studies
- Steady state simulation studies. Load flux
- Steady state simulation studies. Short-circuit
Electrical metrology laboratory for calibration and testing

ICT facilities

- Internet and software tools:
  At the computer laboratories, students will have access to internet and software tools as:
  - PS-CAD
  - DigSILENT
  - CAPE
  - PSS/E
  - Transview
  - Matlab
  - Office

- Moodle application:
  Every student will be enrolled in the unizar-moodle application, where they will find updated information about the course, additional materials, recommended bibliography and upcoming events. Furthermore, they will be able to participate in forums with other students and lecturers.

In the following picture a general view of the moodle structure can be seen.
Information

Requirements
This course is basically meant for the electric sector professional training, from electric enterprises or organization managers and technicians, to recent graduates from technical disciplines that want to orient its career in the sector.

The course is given entirely in English, and it will be essential for students a good English knowledge, though no certificates or level tests will be asked for.

Number of students
To maintain the quality standards this course has a maximum of 25 students. There exists as well the requisite of a minimum number of students for the course to be held.

Material resources
All necessary teaching materials will be provided to students at the beginning of each subject in order to help them follow the lessons.

To achieve the learning outcomes the students are suppose to complete their training with projects, practical work and self-study. Students' personal work will have the support of the Moodle application. Where subjects are activated as the master goes on. Each student will have a username and its password to access at any time on-site lesson’s documents or additional documentation. The students will have as well, via the Unizar web, access to magazines and scientific and technique catalogues of CIRCE Foundation.

Course duration and schedule
The course runs from February to June. Lectures, laboratory hours and activities will be scheduled Monday to Thursday afternoon, and Friday morning, though in some special occasion this could be changed.

Place
The course facilities are held in the University of Zaragoza and CIRCE Foundation inside the Campus “Río Ebro”, where there are also computer facilities for practice lessons.

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Sallán Arasanz, Jesús
Sanz Osorio, José Francisco

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Scarpellini, Sabina

Mechanical Engineering
Uche Marcuello, Javier

Enterprise conferences

**ACCIONA**

The energy division of the ACCIONA Group is a world leader in the field of renewable energy sources. It takes on the mission of demonstrating the technical and economic viability of a new energy model based on criteria of sustainability. ACCIONA Energy has 20 years’ experience in the sector. It is present in seven technologies, has operations in 14 countries, and deploys its activity throughout the value chain. ACCIONA Wind power is a global leader in the development, construction, operation and maintenance of wind power facilities, with over 15 years’ experience.

**DlgsILENT**

It is a consulting and software company providing highly specialized services in the field of electrical power systems for transmission, distribution, generation and industrial plants. DlgsILENT develops the leading integrated power system analysis software covering the full range of standard and highly sophisticated applications including a performance monitoring system.

**ENDESA**

It is the leading utility in the Spanish electricity system and the number one private electricity company in Latin America. It is a significant player in the energy sector of the European Mediterranean region. It also has a growing presence in the Spanish natural gas market and it is advancing rapidly in the area of renewable energy. ENDESA carries out electricity production, distribution and supply activities. It also has stakes in renewable and cogeneration energy facilities representing a combined capacity in service or under construction.

**FORES**

Technological company focussed on renewable energy systems optimization, providing efficiency and safety. Created in 2010 as a spin-off of CIRCE.
RE Grid Integration and Distributed Generation

Foundation for the Development of New Hydrogen Technologies in Aragon
This Foundation was promoted by the Government of Aragon with the aim of carrying out the organization, management and execution of a wide range of actions with the purpose of generating, storing and transporting hydrogen for its use in fuel cells, in transport applications or for the generation of distributed energy.

IBERDROLA
One of the top electric utilities in the world, IBERDROLA has undergone a wide-ranging transformation over the last ten years which has enabled it to advance through the ranks to become the number one Spanish energy group, one of the Spanish main companies on the Ibex 35 by market capitalisation, the world leader in wind energy, and one of the world’s top power companies.

JOFEMAR
A vending leader constantly investing in the areas of technology, research and the development of new products that cover all imaginable requirements in the vending sector.

Mc Phy
McPhy manufactures equipment that optimizes electricity resources based on a unique technology for hydrogen storage in solid form, in association with technology for hydrogen production by water electrolysis that has been reinvented and perfectly adjusted to the production needs of renewable energy.

Red Eléctrica de España
REE is the TSO (Transmission System Operator) of the Spanish power system. Being the owner of 99% of Spain’s high voltage power transmission grid, it is the only company that specialises in the transmission of electricity in Spain. REE, as the system operator, guarantees the continuity and security of the power supply and the proper coordination of the production and transmission system.

SIEMENS
Its Energy Sector is one of the world’s leading suppliers of a wide range of products, solutions and services in the field of energy technology. They enable customers to generate, transmit and distribute electrical power at the highest levels of efficiency. We also help them produce, convert and transport the primary fuels oil and gas. We’re the only manufacturer worldwide with know-how, products, solutions and key components spanning the entire energy conversion chain.

Unión Fenosa Distribución
In 1999 the independent company Unión Fenosa Distribución, S.A. was created. It is responsible for the regulated electricity distribution activity of Grupo Gas Natural Fenosa. Its basic role is to transport electricity from the generation plants and transport network to end users.

ZIV
ZIV is a Crompton Greaves (CG) Group Company. ZIV leads the Automation division of CG and is the centre of excellence for the development of CGs Smart Grids worldwide (Protection, Control, Communications and Metering Solutions).
Program

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Subject 1

Distributed generation

Learning Outcomes
Due to the different backgrounds of the students, in this first subject basic theory and practical knowledge about the electric energy is taught in order to unify their starting point and making it easier for them to apply later concepts. Distribution, stability and power grid quality concepts are revised as well as the effects of renewable energy into the grid. The concept of distributed generation is as well introduced.

Credits: 2

Program

1.2.- Distributed Generation Definition: Integration in power systems. Distributed generation advantages and needs.
Learning Outcomes

Some of the basic aspects of renewable energy generation are shown. Furthermore, storage technologies will be explained for considering their development essential for the success of distributed generation.

Credits: 4,5

Program

2.1.- Wind Power: Wind power generation profiles. Wind power generation advantages and disadvantages. Wind power generation electric features.

2.2.- Photovoltaic and Thermo-solar Power: Types of PV technologies. Building integrate PV systems. Performance indicators in PV installations (kWh/kW, Wp/m², ERF, IRR, etc ….). Aspects for the design of PV systems. The solar PV installation and the net metering. Best practices in integration of PV systems.

2.3.- Biomass Power: General view.


2.5.- Hydrogen Technologies: State of the art (generation, transport and storage). Hydrogen applications and Walqa visit.

2.6.- Power Storage: Battery types. Ultra-capacitors based energy storage systems. Flywheel.

Control techniques and renewable energy integration systems

Learning Outcomes

To study the power electronic basic concepts as a tool for highly efficient process of electric power by means of electronic states. To know the converters and electronic devices developed for the integration of renewable energies.

Credits: 5,5

Program


3.2.- Predictive direct power control of systems connected into the grid.

3.3.- 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.

3.4.- Active Network Devices, Control and FACTS Technology: Theory and operation principle of FACTS. Implementation and FACTS technologies (Series / Shunt compensation).

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 steady state, dynamic or transient 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.

Credits: 6

Program


Subject 5

Smart Grids

Learning Outcomes
Provide students with knowledge in smart grids programming and protection. Present experiences will be shown as well as technologies and devices being used.

Credits: 4,5

Program
5.1.- Smart Grids Programming: Virtual Power Producer. Intelligent reconfiguration including SCADA distributed generators.


5.3.- Case of Study: Distributed Generation Protection: Distributed grids protection. Problems in distributed grids. Solutions.

Learning Outcomes

To know the different law and economic regulations concerning distributed generation for the deregulated markets, and to identify boundaries and opportunities in those fields.

Credits: 2.5

Program


Learning Outcomes

At the end of the course it will be complimentary for every student to hand in an End of Section Project.

Credits: 5