COMILLAS
UNIVERSIDAD PONTIFICIA
ICAI ICADE CIHS

Course 2019-2020

GENERAL INFORMATION

Course information	
Name	Operation and Planning of Future Distribution Networks
Code	DIE-MSG-513
Degree	Master in Smart Grids (MSG)
Year	1st year
Semester	1st (Fall)
ECTS credits	6 ECTS
Type	Mandatory
Department	Electrical Engineering Department
Area	
Coordinator	Lukas Sigrist

Instructor	
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DETAILED INFORMATION

Contextualization of the course

Contribution to the professional profile of the degree

Distribution grids have traditionally been planned and operated with very low level of monitoring and control capabilities. This is the least cost alternative in an environment where demand was predictable and passive. Any potential grid constraint would thus be solved at the planning and connection stages through grid reinforcements.

However, the growth of distributed energy resources (DER), accompanied by fast technological development and cost reductions, are causing profound changes in the way distribution systems are planned and operated. Distribution networks need to become more flexible through the large-scale deployment of electronic devices and information and communication technologies. This new paradigm is known as smart distribution grids.

By the end of the course, students will understand the basic principles behind the planning and operation of distribution networks, understand how distributed energy resources impact these activities, and understand what technical solutions distribution grid operators need to deploy in order to address the new challenges.

Prerequisites

Students willing to take this course should be familiar with the fundamentals on electric power systems. Previous experience with electricity networks and programming languages is also advisable although not required. All these prerequisites can be acquire taking the course on "Fundamentals of Power Systems”.

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CONTENTS

Contents
Introduction: conventional role of distribution companies and new challenges
1. Conventional operation and planning of distribution grids
Role of distribution grids, tasks of distribution companies, conventional approaches to distribution grid planning and operation, grid components, internal organization of a distribution company.
2. New challenges and opportunities in grid planning and operation
Drivers of change (distributed energy resources, consumer empowerment, retail market developments, new business models, ICTs, etc.), the need to adapt grid operation and planning methods.
Innovative network components and grid-edge technologies
1. Innovative network components
Power electronics, sensors, protections, intelligent devices, etc. and their application for network monitoring and control.
2. Grid-edge technologies
Grid-edge technologies and distributed flexibilities: distributed storage, demand response, smart appliances, distributed generation.
3. Distribution operation systems
SCADA, DMS, OMS, NIS. State estimation
Smart grid operation
1. Voltage control
Voltage control in distribution grids, combining grid resources with local flexibility services.
2. Grid monitoring and automation
Grid automation, new monitoring and control devices, outage management, crew management, and distribution grid reliability.
3. Islanded operation and microgrids
Temporary islanded operation, isolated microgrids, unintentional islanding and anti-islanding protection.
4. Smart metering
Smart metering deployment and functionalities: drivers, implications for retail market functioning, costs and benefits, meter functionalities, smart metering data. Lab session/case study: interpreting the data log of a smart meter, testing the automatic disconnection function of smart meters.
5. LV supervision and smart metering data applications

LV data: smart metering and LV supervision. Applications to grid connection, connectivity models, technical/non-technical losses identification, phase unbalance correction, etc.
6. Operational planning under uncertainty
Operational planning, DG and demand forecasting with high granularity, grid reconfiguration for increased hosting capacity, etc.
Grid planning under high shares of DER
1. Impact of DER on network investments
DER-driven incremental network costs, optimal placement of DER, grid connection alternatives, challenges in unbundled contexts.
2. Active network planning
Grid planning under uncertainty (scenario-based and probabilistic planning), non-wire alternatives, smart grid solutions to defer grid investments.
3. Grid planning considering flexibility services
Grid planning and DER contribution: flexibility services, non-frequency ancillary services, local markets.

Competences and Learning Outcomes	
Competences	
C1	Explain traditional planning and operation of distribution networks.
C2	Describe how new DER has affected traditional network planning and operation and the challenges and opportunities they bring about.
C3	Categorize and describe how new devices will impact current power system planning and operation
Learning outcomes	

The objective of the course is for the student to become knowledgeable about the planning and operation of distribution networks. In particular, the specific learning outcomes are:

- LO1. To have acquired the advanced concepts presented in this course, both theoretical and practical, showing a detailed understanding about the conventional approaches to grid planning and operation.
- LO2. To understand the chief technical and economic challenges posed by the penetration of distributed energy resources to distribution system operators.
- LO3. To acquire a working knowledge of the new electronic devices and information systems that are present is smart distribution grids.
- LO4. To understand the applications of smart grid technologies for the operation of distribution systems and the integration of distributed energy resources.
- LO5. To understand the challenges and opportunities that distributed energy resources bring about for distribution network planning.

TEACHING METHODOLOGY

General methodological aspects	
The teaching methodology combines both theoretical sessions and practical sessions that will enable the students to practice and deeply understand the problems faced in the planning and operation of distribution networks. The personal study and the individual/group assignments will complement this classroom training.	
In-class activities	**Competences**
▪ **Lectures** (45 hours): Presentation of the main concepts and procedures, by the instructors. They will include dynamic presentations, case studies, and the participation and interaction with students. ▪ **Practical sessions** (15 hours): use of different software tools to analyse different aspects of the planning and operation of future distribution networks. Lab sessions where students get familiar with different electrical and electronic components of distribution systems. Field visits to actual distribution grid sites.	C1, C2, C3
Out-of-class activities	**Competences**
▪ **Personal study** of the material to be discussed in the lectures (60 hours): This is an individual activity by the students, in which they will read, analyze and question the readings provided as background material, and that will be discussed with other students and lecturers in the classroom	C1, C2, C3
▪ **Individual/Group assignments** (60 hours): Learning activities that will be carried out individually or in small groups, outside of the classroom, and that will require personal research, use of software or commentary of different materials.	C2, C3

ASSESSMENT AND GRADING CRITERIA

Assessment activities	Grading criteria	Weight
Intermediate exams	▪ Multi-choice test and short questions to evaluate the understanding of the concepts	25%
Final exam	▪ Multi-choice test, short questions and problem solving to evaluate the understanding of the concepts	50%
Group/individual case studies and assignments	▪ Application of theoretical concepts to real problem-solving ▪ Ability to use and develop specific software ▪ Ability to understand how electrical and electronic devices operate and their applications in smart distribution systems ▪ Capability to analyze the applications of new smart grid technologies	25%

GRADING AND COURSE RULES

Grading

Regular assessment

The evaluation of the students' learning will comprise two grades: one corresponding to the **written exams**, and the other one corresponding to **the reports on case studies, and group/individual assignments**. **If both grades are larger than, or equal to, 4 out of 10**, the final grade shall be calculated as the weighted average of both grades, giving a weight of **75% to the exams and 25% to the assignment reports**. **Otherwise**, the final grade shall be computed as the **minimum of both previous grades**. In order to pass the course, students must obtain a **final grade of at least 5 out of 10**.

Retakes

Students not passing the course according to the regular assessment criteria shall have a second chance to pass it in a second evaluation period. This retake shall comprise an exam covering the whole course material, including case studies, assignments and computer/lab sessions.

The grade obtained in this retake shall be the final grade of these students. In order to pass the course, students must obtain a final grade of at least 5 out of 10.

No student having passed the course in the first evaluation period shall be allowed to go through the assessment in the second period.

Course rules

- Class attendance is mandatory according to Article 93 of the General Regulations (Reglamento General) of Comillas Pontifical University and Article 6 of the Academic Rules (Normas Academicas) of the ICAI School of Engineering. Not complying with this requirement may have the following consequences:
  - Students who fail to attend more than 15% of the lectures may be denied the right to take the final exam during the regular assessment period.

Students who commit an irregularity in any graded activity will receive a mark of zero in the activity and disciplinary procedure will follow (cf. Article 168 of the General Regulations (Reglamento General) of Comillas Pontifical University).

BIBLIOGRAPHY

Complementary bibliography

Conventional operation and planning:

- T.A. Short. Electric Power Distribution Handbook. CRC Press, 2004
- H. Lee Willis. Power Distribution Planning Reference Book. 2nd Edition, Marcel Dekker, Inc. 2004.

Operation and planning of future distribution grids:

- Buchholz, Bernd M., Styczynski, Zbigniew. Smart Grids – Fundamentals and Technologies in Electricity Networks. Springer 2014.
- “The Future of the Electric Grid”. An Interdisciplinary MIT study, 2011.
- Alberto Sendin, Miguel A. Sanchez-Fornie, Inigo Berganza, Javier Simon, Iker Urrutia. Telecommunication networks for smart grids. Artech House 2016.