COMILLAS UNIVERSIDAD PONTIFICIA ICAI ICADE CIHS

Syllabus 2020 - 2021

TECHNICAL SHEET OF THE SUBJECT

Data of the subject	
Subject name	Operation and Planning of Future Distribution Networks
Subject code	DIE-MSG-517
Involved programs	Master in Smart Grids [Primer Curso]
Level	Master
Quarter	Semestral
Credits	6,0 ECTS
Type	Optativa
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SPECIFIC DATA OF THE SUBJECT

Contextualization of the subject

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".

Competencies - Objectives

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:

- 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.
- To understand the chief technical and economic challenges posed by the penetration of distributed energy resources to distribution system operators.
- To acquire a working knowledge of the new electronic devices and information systems that are present is smart distribution grids.
- To understand the applications of smart grid technologies for the operation of distribution systems and the integration of distributed energy resources.
- To understand the challenges and opportunities that distributed energy resources bring about for distribution network planning.

THEMATIC BLOCKS AND CONTENTS

Contents - Thematic Blocks

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

Computer session: distribution 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.

Computer session: reliability analyses (Matlab).

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.

TEACHING METHODOLOGY

General methodological aspects of the subject

The teaching methodology is focused on 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 Methodology: Activities

- **Lectures**: 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**: 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.

Non-Presential Methodology: Activities

- **Personal study of the material to be discussed in the lectures**: 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
- **Individual/Group Laboratory assignments**: 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.

SUMMARY STUDENT WORKING HOURS

In-class hours:

- Lectures: 40 hours
- Problem-solving and Laboratory sessions: 15 hours
- Assessments: 5 hours

Out-of-the-class hours:

- Self-study: 85 hours
- Report preparation: 35 hours

EVALUATION AND CRITERIA

Mid-term exam

- Multi-choice test and short questions to evaluate the understanding of the concepts

Final Exam

- Multi-choice test and short questions to evaluate the understanding of the concepts

Laboratory reports

- 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

Ratings

In order to pass the course, the mark of the final exam must be greater or equal to 4 out of 10 points and the laboratory mark must be at least 5 out of 10 points. Otherwise, the final grade will be the lower of the two marks.

The final grade will be calculated as follows:

- Mid-term exam will account for 25%
- Final Exam will account for 60%
- Laboratory reports will account for 15%

Retakes:

Lab marks will be preserved as long as the weighted average of all the sessions results in a passing grade. Otherwise a new lab reports will be handed in. It is up to the professor criteria to modify the content of the laboratory sessions so that they are not the same as the ones developed over the course. In addition, all students will take a final exam. The resulting grade will be computed as follows:

- Theory will account for 70%. Only the retake exam will be considered.
- Lab will account for the remaining 30%

As in the regular assessment period, in order to pass the course, the mark of the final exam must be greater or equal to 4 out of 10 points and the mark of the laboratory must be at least 4 out of 10 points. Otherwise, the final grade will be the lower of the two marks

BIBLIOGRAPHY AND RESOURCES

Basic Bibliography

Notes provided by the lecturers.

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.