COMILLAS
UNIVERSIDAD PONTIFICIA
ICAI

COURSE SYLLABUS 2025-2026

GENERAL INFORMATION

Course information	
Name	Network Business: Transmission, Distribution and Smart Grids
Code	
Degree	Master in the Electric Power System (MEPI)
Year	
Semester	2nd (Spring)
ECTS credits	6 ECTS
Type	Elective
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DETAILED INFORMATION

Contextualization of the course

Contribution to the professional profile of the degree

The liberalization process experienced by power systems during the last decades resulted in the introduction of competition in wholesale and retail electricity markets. However, network activities, considered as natural monopolies, remain under regulation. This course is focused on the fundamentals and the regulation of the two network industries: transmission and distribution of electricity. Additionally, the increasing deployment of distributed energy resources (DER) is introducing significant changes in the planning and operation of distribution networks, which are transforming more and more rapidly to smart grids.

By the end of the course, students will understand the basic principles behind the regulation of network industries, will be able to critically understand the regulation of transmission and distribution in different countries, and will know the motivations and the current and future expectations about the transformation of distribution networks into smarter grids.

Prerequisites

Students willing to take this course should be familiar with fundamentals on electric power systems. Previous experience with regulation, economics and programming languages is also desired although not required.

CONTENTS

Contents

Transmission

1. Background concepts

The transmission activity. Modeling transmission networks in power systems decision support tools. Nodal pricing: concepts, computation and properties.

2. Regulatory issues

Short term economic signals: ohmic losses and congestion management. Long term economic signals: network remuneration and tariffs. Access issues. Transmission planning.

3. Business activities

Description of the organization of a Transmission Owner. Examples of activities: Access and expansion planning decision making in the Spanish TO (REE); Large interconnection system studies of the Spanish TO (REE).

4. Interconnected power systems

Transmission network regulation within regional markets.

Distribution

1. Fundamentals on regulation

Different regulatory alternatives. Distribution costs, CAPEX, OPEX, asset base.

2. Quality of service and network losses

Regulation of power quality. Incentives for improving quality of service and reducing network losses.

3. International experiences

Implementation of distribution regulation in selected countries.

Smart grids

Drivers and technological development. Distributed Energy Resources, New roles of DSOs. Grid access and connection for DER. New regulatory approaches.

Competences and Learning Outcomes

Competences

General Competences

Basic Competences

CB1 Haber adquirido conocimientos avanzados y demostrado, en un contexto de investigación científica y tecnológica o altamente especializado, una comprensión detallada y fundamentada de los aspectos teóricos y prácticos y de la metodología de trabajo en uno o más campos de estudio.

Specific Competences

CE13 Comprender la función de la red de transporte y de la red de distribución en el suministro de electricidad, así como de su integración con el resto de las actividades eléctricas, tanto desde un punto de vista técnico como regulatorio o económico

CE14 Conocer en profundidad los principios económicos que subyacen a las alternativas de regulación para las actividades de transporte, e identificar y saber evaluar los diferentes conceptos de coste por los que las empresas distribuidoras deben ser remunerada: costes de operación y

	mantenimiento, amortización de infraestructuras, tasa de retorno sobre el capital invertido, gestión comercial, tributos e impuestos, etc.
CE15	Entender el impacto que la generación distribuida produce sobre las redes convencionales, y las implicaciones técnicas, económicas y regulatorias que tendrán las redes inteligentes en el futuro.

Learning outcomes

The objective of the course is for the student to become knowledgeable about the network business of electricity systems. In particular, the specific learning outcomes are:

RA1.	To have acquired the advanced concepts presented in this course, both theoretical and practical, showing a detailed understanding about the regulation of network business, and about the main characteristic of network business.
RA2.	To understand the chief technical and economic characteristics that make the transmission and distribution networks a natural monopoly and therefore subject to regulation, distinguishing between how to use short- and long-term economic signals.
RA3.	To acquire a working knowledge of the various regulatory alternatives for decision-making with respect to transmission network investment and to understand and to be able to evaluate the various alternatives proposed to regulate transmission network access in the event of transmission constraints.
RA4.	To understand the fundamentals of electric distribution business and regulation and to identify the different regulatory alternatives proposed to regulate economically the distribution business.
RA5.	To understand the role of smart grids in future distribution networks and to acquire the knowledge about the different alternatives regarding smart grids in transmission and distribution networks.

TEACHING METHODOLOGY

General methodological aspects

The teaching methodology combines both theoretical sessions (included invited speakers from the industry) and practical sessions that will enable the students to practice and deeply understand the problems faced in the regulation of network industries. The personal study and the individual/group assignment will complement this classroom training.

In-class activities	Competences
▪ **Lectures and in-class discussions** (60 hours): Presentation of the main concepts and procedures, by the instructor and professionals from the power sector. They will include dynamic presentations, case studies, and the participation and interaction with students.	CB1, CE13, CE14, CE15
Out-of-class activities	**Competences**
▪ **Personal study** of the material to be discussed in the lectures (75 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.	CB1, CE13, CE14, CE15
▪ **Out-of-class assignments** (45 hours): Learning activities that will be carried out outside of the classroom, and that may include individual or group assignments, exercises, problem solving, or personal research.	CE13, CE14, CE15

ASSESSMENT AND GRADING CRITERIA

Assessment activities	Grading criteria	Weight
Transmission 1st Mid-term exam	▪ Multi-choice test and short questions to evaluate the basic understanding of the concepts	11,25%
Transmission 2nd Mid-term exam	▪ Multi-choice test and short questions to evaluate the basic understanding of the concepts	11,25%
Transmission 3rd Mid-term exam	▪ Multi-choice test and short questions to evaluate the basic understanding of the concepts	4,5%
Transmission Group assignments	▪ Application of theoretical concepts to real problem-solving ▪ Collection and critical review of information on transmission regulation ▪ Ability to use and develop specific software	18%
Distribution Mid-term exam	▪ Multi-choice test and short questions to evaluate the basic understanding of the concepts	11%
Distribution Final exam	▪ Multi-choice test and short questions to evaluate all topics dealt with during the course	27,5%
Group and individual case studies	▪ Application of theoretical concepts to real problem-solving ▪ Ability to use and develop specific software ▪ Capability to analyze the regulatory implications of numerical results	16.5%

GRADING AND COURSE RULES

Grading

Regular assessment

The evaluation of the students' learning will comprise two grades: one corresponding to the **transmission** lectures, and the other one corresponding to **distribution** and smart grids.

The evaluation of the transmission part will be based on exams (60%) and other aspects of the assessment (40%). The evaluation of distribution and smart grids will be based on exams (70%) and other aspects of the performance assessment (30%). This applies as long as the overall grade corresponding to the exams in each of these parts, i.e. transmission and distribution, (applying the corresponding weights) is above 3.5 over 10. Otherwise, the final grade in the part when this last condition is not met will be computed as the global grade for the exam in that part.

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 **45% to transmission and 55% to distribution** and smart grids. **Otherwise**, the final grade shall be computed as the **minimum between 4 out of 10 and this weighted average**. 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 at the end of June. This retake shall comprise an exam for each part of the course (transmission, or distribution and smart grids) where the student has not obtained a grade of at least 5 out of 10.

The grade for the transmission retake will be computed considering both the grade obtained in this exam as well as the group assignment considering the same weights as in the regular assessment. The grade of the group assignment will be kept from the regular assignment when the student had a grade equal or higher than 5. In those cases where the grade obtained in the retake exam is lower than 3.5 and/or the grade the student had obtained in the group assignment in the regular assessment period were below 5, the grade of the transmission retake will be the grade obtained in the exam of the retake.

The grade of the distribution retake will exclusively correspond to the distribution retake exam in all cases.

The grade obtained in this retake shall be the final grade of these students for the corresponding part or parts. For those parts (transmission, or distribution and smart grids) where the student has obtained at least a 5 out of 10 in the regular assessment period, students will keep this grade. Provided that the student has obtained a **final grade of at least 5 out of 10 in both parts** (transmission and distribution and smart grids), the final grade shall be calculated as the weighted average of the grades obtained by the student in each of the two parts of the course, giving a weight of **45% to transmission and 55% to distribution** and smart grids. Otherwise, the final grade shall be minimum between the grades obtained in the two parts of the course.

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).

WORK PLAN AND SCHEDULE[1]

In and out-of-class activities	Date/Periodicity	Deadline
Mid-term exam	Weeks 7, 8, 14, 17	
Final exam	Week 17	
Review and self-study of the concepts covered in the lectures	After each lesson	
Problem-solving	Occasionally	

[1] A detailed work plan of the subject can be found in the course summary sheet (see last page). Nevertheless, this schedule is tentative and may vary to accommodate the rhythm of the class.

Assessment preparation	Weeks 6, 7, 13, 16, 17	
Distribution case study preparation	Weeks 4, 7, 9	Weeks 7, 10, 12
Transmission Group Assessment	During the last half of the course	Week 17
Final exam preparation	May	Week 17

STUDENT WORK-TIME SUMMARY		
IN-CLASS HOURS		
Lectures and in-class discussions: Presentation of the main concepts and procedures, by the instructor and professionals from the power sector. They will include dynamic presentations, case studies, and the participation and interaction with students		
60		
OUT-OF-CLASS HOURS		
Personal study of the material to be discussed in the lectures: individual activity, 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	Out-of-class assignments: Learning activities that will be carried out outside of the classroom, and that may include individual or group assignments, exercises, problem solving, or personal research	
75	45	
	ECTS credits:	**6 (180 hours)**

BIBLIOGRAPHY

Basic bibliography

Perez-Arriaga, Ignacio J., Regulation of the Power Sector. Springer. 2013

- Chapter 4: Monopoly Regulation
- Chapter 5: Electricity Distribution
- Chapter 6: Electricity Transmission
- Chapter 10: Regional Markets
- Chapter 14: Challenges in power Sector Regulation

Complementary bibliography

Texts related to competition schemes within the Electrical Sector:

- International Energy Agency (2001) Competition in electricity markets. OECD.
- Hunt, S., Shuttleworth, G. (1996) Competition and choice in electricity. Wiley.
- Hunt, S. (2002) Making competition work in electricity, Wiley Finance.
- Stoft, S. (2002) Power System Economics, Wiley-IEEE Press.

Power Systems technology and economic bases with emphasize on transmission topics:

- Schweppe, F.C., Caramanis, M.C., Tabors, R.D., Bohn, R.E. (1988) Spot pricing of electricity. Kluwer Academic Publishers.
- Wood, A.J., Wollenberg, B.F., (1984) Power generation, operation and control. John Wiley.
- Levêque, F. (editor) Transport pricing of electricity networks, Kluwer, 2003.
- Woolf, F. (2003) Global Transmission Expansion. Recipes For Success. PennWell.

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- T.A. Short. Electric Power Distribution Handbook. CRC Press, 2004

- H. Lee Willis. Power Distribution Planning Reference Book. 2nd Edition, Marcel Dekker, Inc. 2004.
- Incentive Regulation in Theory and Practice: Electricity Distribution and Transmission Networks. Paul L. Joskow, 2006
- R. Cossent. Economic regulation of Distribution System Operators and its adaptation to the penetration of Distributed Energy Resources and smart grid technologies. PhD Thesis, Comillas University. 2013.