IDS.505, 6.695J, 15.032J
ENGINEERING, ECONOMICS AND REGULATION OF THE ELECTRIC POWER SECTOR
SYLLABUS
Carlos Batlle, Scott Burger & Ignacio J. Pérez-Arriaga
Spring 2019

Instructors:

Prof. Carlos Batlle (Room E19-307, CBatlle@mit.edu)
Scott Burger (E19, MITEI, 3rd floor; SBurger@mit.edu)
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Teaching Assistants:

TBC (TBC@mit.edu)

Level: H-Level Graduate. Preferably with background in policy analysis, microeconomics and/or engineering/science. Open to advanced undergraduates with permission of instructor.

Units: (3-0-9)

Course number: IDS.505, 15.032J, 6.695J

Meetings: Tue (lecture) – Thu (lecture) - Fri (recitation) 10:30-12:00

Classroom: E51-395 (lectures) and E51-057 (recitation)

Stellar site: https://stellar.mit.edu/S/course/IDS/sp19/IDS.505/

Description:

The course presents an in-depth interdisciplinary perspective of the electric power sector, with regulation providing the link among the engineering, economic, legal and environmental viewpoints.

Electricity markets, incentive regulation of networks, reliability of service, renewable energy sources, contemporary network issues, retail competition, tariff design, distributed generation, rural electrification, multinational electricity markets, environmental impacts, future of utilities and strategic sustainability issues will be addressed under both traditional and competitive regulatory frameworks.

The course will make available the engineering, economic and legal basis to critically evaluate the regulatory instruments that are used worldwide for electricity supply activities that are performed as regulated monopolies or under competitive conditions. Most of these regulatory approaches are also of application in other industrial sectors.

The knowledge acquired in the course will provide the comprehensive understanding of electric power systems that will be needed for research in this field, as well as for future professional activities in the energy sector, whether in industry, government or consulting.
PROGRAM

The material of the course and the learning process of the students is organized according to three layers, in increasing level of complexity and depth, each one corresponding to a different perspective on the power sector:

• First layer: An introduction to power systems, the regulatory function and how it has been performed traditionally.

• Second layer: The economic principles of regulation of monopolies and markets. The application of these principles to the regulation of the different activities that are necessary for the supply of electricity: generation, distribution, transmission, retailing and system operation.

• Third layer: Transversal topics generally involving more than one activity or some advanced issues, closing with a look at the future.

The recitations are focused to review real-life case examples presented by the instructors or guest speakers providing the diverse views of the industry stakeholders.

Module A: Power systems operation and management: Technology, economics and regulation

How do electric power systems manage to provide electricity continuously with an adequate quality of service, at an affordable price and with an acceptable environmental impact?

• Sessions 1, 2 & 3. Introduction to the course and to Electric Power Systems (EPS)

  Motivation: What the course is about. Organization issues.


  Economics & management: Global view of an EPS from an economic and managerial perspective. Organization of the power sector. The hierarchy of decision-making processes in the traditionally regulated power sector. Equivalent functions under a competitive regime.

    Homework HW1. Explore the “Resources” document. Selection and preliminary characterization of a specific existing power system.

• Recitation 1. Topics in power systems engineering

  Discussion on technologies in power systems. General doubts and questions for those without a power systems engineering background. AC versus DC. Real & reactive power. Networks. Stability issues. Formulation of power system models. Other topics.

Module B: The regulatory function. Traditional regulation of electric power systems

Does the electric power sector need to be regulated and, if so, what kind of regulation does it need?

• Session 4. The regulatory function. What should and should not be regulated. Regulatory authorities: Functions and organization

  Introduction to the traditional regulation of the electric power sector. Cost-of-service remuneration. Weak and strong points of the traditional approach. Transition to market-based regulatory frameworks.

• Recitation 2. What is regulation about? Awakening our regulatory mindset.
**Module C: Regulation of monopolies**

How to regulate a network monopolistic activity, such as distribution of electricity? Under which conditions would an electric utility provide distribution network services efficiently and with an adequate quality of service?

- **Session 5.**

- **Session 6.**
  Economic, technical and regulatory characterization of the distribution activity. Investment, pricing and access. Incentive schemes to move towards optimal levels of network losses and quality of service. Distributed generation and other current challenges in distribution regulation.

  Homework HW3. Regulatory function and traditional regulation. Description of the regulatory framework and regulation of the distribution activity in the power system of interest.

- **Recitation 3.** Life as a regulated utility. Guest speaker: Edward Young. Director of US strategy at National Grid (TBC).

**Module D: Principles of microeconomics applied to electricity markets**

Competitive markets or traditional regulation? What are the economic principles supporting electricity markets?

- **Session 7.** Principles of microeconomics applied to EPS
  Principles of Microeconomics. Relationships between the traditional and competitive regulatory frameworks. Equivalences among remuneration schemes. Factors affecting the expectation of cost recovery.

  Homework HW4. Microeconomics and fundamentals of electricity markets.

- **Recitation 4.** Liberalization of electricity markets. Prof. Ignacio J. Pérez-Arriaga

**Module E: Electricity generation: theory and practice of wholesale electricity markets**

Competitive markets or traditional regulation? What are the economic principles supporting electricity markets? How to design, implement and monitor an efficient, reliable and environmentally adequate system of electricity production? How do wholesale markets function? How can market power be exercised?

- **Sessions 6 & 7.** Design and implementation of wholesale electricity markets

- **Recitation 5.** Operating in wholesale electricity markets. Real-life case examples.

- **Sessions 8 & 9.** Reliability complements for energy markets: Ancillary and capacity mechanisms
  Can energy-only markets be trusted to attain an adequate level of investment in generation capacity? What regulatory instruments (if any) could be used to promote short-term security and additional investment? Is there any successful experience?

  Homework HW5. Wholesale electricity market design in the power system of interest.
Module F: Transmission

What is the impact of the transmission network on the functioning of wholesale electricity markets? How to succeed in making investment in transmission networks happen in the right amount, at the right times and at minimum cost for the users?

- **Session 10. Transmission principles & investment**

- **Session 11. Transmission cost allocation and contracts for network capacity**

  Homework HW6. Transmission investment, access and pricing.

- **Recitation 7.** “Slack” session. HWs discussion and other topics.

Module G: Regional electricity markets.

What is the justification of establishing regional/multinational electricity markets? What are the new regulatory topics to be considered in the regional context? What can be learned from existing international experiences?

- **Session 12. Regional markets implementation issues**
  Case study: The struggle to find a seamless method to integrate national electricity markets into a Single Electricity Market. Lessons to be learned from the EU and the American continent.

Module H: Energy markets and environmental policy objectives

What is different in generation from renewable energy sources with respect to generation from other sources? What is the justification of separate regulatory regimes? Which regulatory instruments have been used and/or proposed to promote renewables? Which ones have worked and which ones have not and why?

- **Session 13. Mechanisms of promotion of renewables and energy efficiency**
  Justification of ad hoc regulatory regimes for generation of electricity from renewable energy sources and energy efficiency. Critical evaluation of existing and proposed regimes for promotion of renewables.

  Homework HW7. Renewable support mechanisms in the power system of interest.


Module I: Electricity tariff design

How are the costs of the different activities reflected in the prices that final consumers have to pay for the electricity that they use?

- **Session 14.** Classical tariff design
Basic principles: sustainability, efficiency, additivity, non-discrimination, transparency, simplicity. Specific treatment of each activity.

- **Session 15. Tariff design in less traditional contexts**
  Significant presence of distributed energy resources and large volumes of intermittent generation. The treatment of self consumption.

- **Recitation 9. Models for power system planning, markets, and operations**

**Module J: Retail markets**

Does it make sense to extend retail competition to all the end consumers? How should retail markets be implemented? How to achieve an active participation of demand in the functioning of the power system? What roles should play electric distribution utilities in promoting energy efficiency and responsive energy?

- **Sessions 16 & 17. Retail markets**
  The debate on the extension to all consumers. Convenience and design of default and last resort tariffs. Demand response. Advanced metering and its implications. Hurdles to the successful deployment of retail markets.

  Homework HW8. End-user pricing. Tariffs and retail.


**Module L: Gas and electricity markets.**


- **Session 18. Gas and electricity markets**
  Models to analyze the interaction between them. Common regulatory issues.

**Special module M: System Operation in practice.**

How are the security and economic functions - involving generation, transmission and demand - actually implemented?

- **Special recitation 10. Visit to the ISO-New England control center**
  Secure operation, daily market, ancillary services, renewables, capacity expansion, etc.

**Module N: Power systems of the future**

What will be the defining characteristics of the electric utility of 2025, the successful business models, the regulatory trends and the transformative technologies?

- **Sessions 21 & 22.**
  Challenges and opportunities derived from the current and anticipated large deployment and aggregation of intermittent renewable generation sources, electric vehicles, advanced distribution automation and metering, demand response and cybersecurity.

- **Recitation 11. New strategies for electric utilities. Guest speaker (Enel or Enernoc, TBC).**
Module O: Universal access to electricity.

How many people still lack access to electricity? What is the impact on human development? What has been the impact of the recent regulatory reforms on access to electricity? What could be adequate approaches to achieve universal electricity access?

- **Sessions 23 & 24. Regulatory challenges for universal electricity access**
  Review of international experiences of electricity reform and their impact on universal electricity access.
  Elements of successful programs of rural electrification. Extension of the major grid and supply to dispersed population.

- **Recitation 12.** Topic to be determined.

Module P: Restructuring, Competition and Regulatory Reform in the U.S. Electricity Sector.

- **Session 25** Prof. Paul L. Joskow, Elizabeth and James Killian Professor of Economics, Emeritus at MIT.

Presentation of the term papers.

- **Session 26.** Presentation of the term papers
  An extended schedule will be used on that day and probably also the following ones (depending on the number of students), so that all papers will have sufficient time for presentation and discussion. During the presentation of the term papers, questions will be asked on the material presented in the compilation document.

  The course schedule specifies the dates when the homework compilation documents and the term papers are due.

Textbook


How to get the book? Please, go to the “Resources” document in the Stellar website for the course.

Calculating final grades

Recitations are not mandatory, but they are strongly recommended. They will be taught by the course instructors and many of them will include a lecture led by a guest speaker that will cover relevant topics that will complement the core content of the course. Some of them will be partly devoted to discuss the homework assignments.

The final grade for the course will be computed based on the take-home assignments (50%) and a final term paper (50%), including presentation and discussion. Participation in class (lectures and recitations) will be taken into account when determining the final grade.

Attendance to lectures is mandatory and will be taken into account for the final grade. No more than two non-justified absences will be needed to obtain a pass grade.

Student Support Services

If you are dealing with a personal or medical issue that is impacting your ability to attend class, complete work, or take an exam, please discuss this with Student Support Services (S3). The deans in S3 will verify your situation, and then discuss with you how to address the missed work. Students will not be excused from coursework without verification from Student Support Services. You may consult with
Student Support Services in 5-104 or at 617-253-4861. Also, S3 has walk-in hours Monday-Friday 9:00-10:00am.

**Student Disability Services**

MIT is committed to the principle of equal access. Students who need disability accommodations are encouraged to speak with Kathleen Monagle, Associate Dean, prior to or early in the semester so that accommodation requests can be evaluated and addressed in a timely fashion. Even if you are not planning to use accommodations, it is recommended that you meet with SDS staff to familiarize yourself with the services and resources of the office. You may also consult with Student Disability Services in 5-104 or at 617-253-1674. If you have already been approved for accommodations, please contact me early in the semester so that we can work together to get your accommodation logistics in place.

**Policy on classroom behavior**

**MIT Sloan Policy on Classroom Behavior**

In order to create a productive learning environment and to ensure mutual respect it is essential that the norms and rules of classroom etiquette and behavior reflect the highest standards. It is also important that these norms be consistently enforced by the faculty across all classes. Although in the final analysis each faculty member is responsible for his or her own classroom, there are significant negative consequences for other faculty and for the School if rules are not consistent and are not enforced. Therefore it is the policy of the MIT Sloan School that

- Students are expected to arrive promptly on time and to stay for the entire class.
- Faculty are expected to begin and end class on time.
- Laptops and e-readers not be open in the classroom except with explicit permission of the faculty (e.g., when used to deliver an e-course pack or otherwise used as part of the instructional program, or when required by students because of physical or other challenges)
- Cellphones and PDAs are not to be used or permitted to ring in the classroom.
- Students are expected to attend all classes.

Please note that in accordance with this policy, students are required to schedule campus interviews outside of scheduled class times and to make every attempt to schedule second round interviews and site visits outside of class times. Classes missed for such activities are not excused absences and may count against your participation grade.