200638 - OSME - Optimization in Energy Systems and Markets

Coordinating unit:	200 - FME - School of Mathematics and Statistics
Teaching unit:	715 - EIO - Department of Statistics and Operations Research
Academic year:	2015
Degree:	MASTER'S DEGREE IN STATISTICS AND OPERATIONS RESEARCH (Syllabus 2013). (Teaching unit Optional)
ECTS credits:	5 Teaching languages: Spanish

Teaching staff

Coordinator:	FRANCISCO JAVIER HEREDIA CERVERA
Others:	
	CRISTINA CORCHERO GARCIA - A
	FRANCISCO JAVIER HEREDIA CERVERA - A

Opening hours

Timetable:	By appointment.

Prior skills

- Fundamentals on continuous and integer optimization.
- Stochastic programming modeling.
- Mathematical programming languages (AMPL, GAMS, SAS/OR,...)

Requirements

- A background equivalent to the courses Continuous Optimization, Integer and Combinatorial Optimization and Stochastic Programming is recommended.

Degree competences to which the subject contributes

Specific:
1. CE-2. Ability to master the proper terminology in a field that is necessary to apply statistical or operations research models and methods to solve real problems.
2. CE-5. Ability to formulate and solve real problems of decision-making in different application areas being able to choose the statistical method and the optimization algorithm more suitable in every occasion.
Translate to english
3. CE-7. Ability to understand statistical and operations research papers of an advanced level. Know the research procedures for both the production of new knowledge and its transmission.
4. CE-9. Ability to implement statistical and operations research algorithms.

8. CE-3. Ability to formulate, analyze and validate models applicable to practical problems. Ability to select the method and / or statistical or operations research technique more appropriate to apply this model to the situation or problem.
9. CE-6. Ability to use appropriate software to perform the necessary calculations in solving a problem.

10. CE-8. Ability to discuss the validity, scope and relevance of these solutions and be able to present and defend their conclusions.
Transversal:
5. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding how companies are organised and the

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principles that govern their activity, and being able to understand employment regulations and the relationships between planning, industrial and commercial strategies, quality and profit.
6. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.
7. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Teaching methodology

The course will combine both theoretical and practical sessions:
- The theoretical sessions will be devoted to define and explain the rationale of the different problems arising in centralized and market operation of energy systems problems, its formulation as deterministic or stochastic programming problems and the study of the properties of these models.
- During the practical sessions (at least 1/3 of the total course) all the models developed in the theoretical lectures will be implemented in AMPL and used as a computational tool to analyse the properties of the optimal solutions to the energy systems and markets operations.

The official language of the course is Spanish, but English-speaking students are warmly welcomed. All the material of the course is in English, and students will be assisted in English if necessary, either in class and during office hours.

Learning objectives of the subject

Students passing this course are expected:

- To be aware of the main characteristics of the countrywide energy production system.
- To know an be able to formulate and solve the fundamental problems in the centralized operation of energy systems (Economic Dispatch, Optimal Power Flow, Unit Commitment).
- To understand the structure and rules of the electricity markets (day-ahead, regulation, adjustment, bilateral and futures), and to know the properties and how to compute the equilibrium point (clearing) for some of these markets through the corresponding market clearing mathematical optimization model.
- To understand the diverse sources of uncertainty in the operations of electricity market, how to the represent these uncertainties, together with some measure of risk, through probability scenarios and the appropriate stochastic programming modelization.
- To understand the characteristics and properties of the different market operation problems (optimal producer's generation bid, optimal consumer's purchase bid, optimal medium-term retailer trading).
- To be able to formulate, to develop the computational implementation and to find the optimal solution of the stochastic programming model for any market operation problem.

Study load

Total learning time: 125h			
	Hours large group:	30h	24.00%
	Hours small group:	15h	12.00%
	Self study:	80h	64.00%

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Content

Introduction : centralized vs. market operation of energy systems.	Learning time: 1h 30m Theory classes: 1h 30m

Description:
 The wholesale national energy production system.
 Countrywide centralized vs. liberalized energy systems.
 Electricity markets organization.

Optimization of centralized energy systems operations.	Learning time: 9h Theory classes: 9h

Description:
 Generation units modeling.
 Economic Dispatch
 Optimal Power Flow.
 Unit Commitment

Market clearing models	Learning time: 9h Theory classes: 9h

Description:
 Utility functions, producers and consumers surplus, Social Welfare, market equilibrium conditions.
 Single Period Auction model.
 Multiple-Period Auction model.
 Transmission Constrained Auction models: nodal prices.

Uncertainty in electricity markets	Learning time: 6h Theory classes: 6h

Description:
 Sources of uncertainty in electricity markets.
 Uncertainty characterization via scenarios: algorithms for scenario generation and reduction.
 Risk management.

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Optimal market operations for electricity producers	Learning time: 9h Theory classes: 9h

Description:
Spot markets: day-ahead, regulation and adjustment markets.
Scenario tree for spot markets.
Stochastic programming models for the optimal generation bid.
Risk modeling.

Optimal market operations for retailers and consumers.	Learning time: 9h Theory classes: 9h

Description:
Stochastic programming models for the energy procurement by consumers: uncertainty characterization; bilateral contracts, pool and self-production; consumer model.
Stochastic programming models for the medium-term retailer trading: uncertainty model; market structure; retailer model.

Qualification system

The final grade of the course will be based on a series of laboratory assignments where the students will be asked to formulate, implement with AMPL (or any other mathematical programming language) and analyse some market and energy systems operations problems similar to the ones studied during the course.

Bibliography

Basic:

Gómez Expósito, Antonio; Conejo, Antonio J; Cañizares, Claudio. Electric energy systems : analysis and operation. Boca Raton: CRC Press, 2009. ISBN 978-0-8493-7365-7.

Conejo, Antonio J.; Carrión, Miguel; Morales Juan M. Decision making under uncertainty in electricity markets. Springer, 2010. ISBN 978-1-4419-7420-4.

Zhu, Jizhong. Optimization of power system operation. Piscataway, N.J.: Wiley-IEEE, 2009. ISBN 978-0-470-29888-6.

Complementary:

Pérez-Arriaga, Ignacio J. (Ed.). Regulation of the power sector [on line].   2013Available on: <http://dx.doi.org/10.1007/978-1-4471-5034-3>. ISBN 978-1-4471-5033-6.