



ESF Exploratory Workshop
on
Mathematical Models for Electricity Markets

Castilla – La Mancha University, Campus Universitario, Ciudad Real, Spain
July 13-14, 2006

Scientific Report

Ciudad Real, September 4, 2006

Co-sponsored by



1. Executive summary (approx. 2 pages)

The ESF Exploratory Workshop “Mathematical Models for Electricity Markets” took place at the University of Castilla – La Mancha, Ciudad Real, Spain on July 13-14, 2006. It was attended by 29 world-wide leading scholars and practitioners from 16 countries and 3 continents including economists, operations research specialists and power engineers.

The workshop was aimed at promoting much-needed innovative paradigms and ideas for electricity market design. It explored state-of-the-art mathematical models for such markets. These models address the viewpoints of the producers, the consumers, and the market and system operators. They require tools such as stochastic programming, equilibrium analysis, large-scale optimization, and risk and security studies. These models are of crucial importance for the efficient functioning of electricity markets.

The workshop has focused on state-of-the-art mathematical models pertaining to electricity markets, including energy and ancillary services. Themes include:

- a) New problems and opportunities for market modeling.
- b) Strategic modeling of the behavior of market participants.
- c) Advances in large-scale optimization tools.
- d) Recent advances in large-scale equilibrium programming.
- e) Large-scale stochastic programming applications.
- f) Risk modeling in electricity markets, including regulatory and others.

The workshop included five sections that allowed the participants to present and discuss their respective works.

The workshop also included two plenary presentations by Prof. Smeers from Univ. Catholique de Louvain, Belgium on the ability to model market power, and by Dr. O’Neill from the Federal Energy Regulatory Commission, USA on electricity market design.

It also included three questionnaire sessions that allowed to identify the most relevant “electricity market” problems according with the participants.

The workshop developed smoothly and included 29 presentations and lively discussions. Coffee breaks, lunches and the workshop dinner allowed for further discussions on technical topics.

It is particularly relevant to note that personal relations among participants were either strengthen or created. Fruitful future collaborations among participants are expected.

Meeting and discussion facilities were very appropriate and according to most participants the hotel was most adequate and conveniently located.

The general opinion of the participants on the workshop was very good, as indicated by the message sent by Prof. Galiana to the convenor reproduced below “In my view, the workshop was a great success, all participants having benefited significantly in a number of ways. I very much appreciated the venue, a comfortable, yet relatively compact room with good acoustics, in which all participants could readily interact from their seats around a horse-shoe-shaped table. The spirited discussions that followed each presentation were a sure sign that the formula worked. Our hotel was within easy walking distance to the workshop site and the support staff was all very helpful and efficient. There was a good mix of some of the world’s top experts from the areas of economics, operations research and power systems, all clearly very much involved in electricity markets. My main aims were fully attained by having learned a significant amount and especially by the opportunity to meet researchers with different points of view and background. As a result of this exploratory workshop I plan to pursue further collaboration with a number of researchers in the area of strategic bids and offers in electricity markets.”

2. Scientific contents of the event (minimum 1 page, no abstracts)

The discussions were arranged in five sessions.

1. Pricing and bidding strategies. This section included presentations by Dr. Arroyo, Dr. Barroso, Prof. Green, Prof. Guan and Dr. Kockar. The session focused on retailer strategies, bidding strategies, price behavior, electricity portfolio management and pricing paradigms (marginal vs. pay-as-bid).
2. Market behavior and simulation. This section included presentations by Prof. Bakirtzis, Prof. Conejo, Dr. Oliveira, Dr. Pogrebnyak and Prof. Galiana. The session focused on producer strategies, consumer electricity procurement, interaction between the pool and long-term contracts, Russian electricity market and Nash equilibria in electricity markets.
3. Congestion management and ancillary services. This section included presentations by Prof. Jörnsten, Dr. Leuthold, Dr. Willems, Dr. Martínez, Dr. Zhong and Prof. Kirschen. The session focused on congestion management, transmission expansion, automatic generation control, reactive power markets, and reserve modeling based on probabilistic criteria.
4. Operations and planning under uncertainty. This section included presentations by Prof. Shultz, Dr. Newhoff, Dr. Saraiva, Prof. Shahidehpour and Dr. Fleten. The session focused on mathematical models for risk modeling, wind power investment, non-conventional techniques for uncertainty treatment, risk-constrained generation scheduling and hydroelectric scheduling under uncertainty.
5. Equilibria models. This section included presentations by Dr. Barquín, Dr. Hers, Prof. Hobbs, Mr. Kuzidem, Prof. Oren and Prof. Ralph. The session focused on electricity market equilibria, equilibria with emission constraints, formulation of market equilibria; formulation, application and computational issues pertaining to equilibria models for electricity markets.

The two plenary sessions address the hot topics “Toward a complete market design improving efficiency and reliability of electricity markets” and “How well can one measure market power in restructured electricity systems?”, respectively.

The workshop also included three questionnaire sessions that allowed to identify the most relevant “electricity market” problems according with the participants.

3. Assessment of the results, contribution to the future direction of the field, outcome

The workshop developed smoothly. The time schedule was carefully respected. All scheduled presentations but one were carried out. The spirited discussions that followed each presentation were a sure sign that the workshop worked.

Participants with different points of view and background either strengthened or developed new personal relations and many participants express their plan to pursue further collaboration with a number of researchers in the area of electricity markets.

Many challenging technical issues were presented and lively discussed. The specific topics analyzed can be checked in Section 2 of this Scientific Report.

A special section in the IEEE Transaction on Power System (leading journal in electricity markets) is being arranged by A. J. Conejo and B. Hobbs on a subset of the topics addressed in the workshop. This special section has been already approved by the Editor in Chief of the aforementioned journal, V. Vittal.

In summary, the workshop was a great success, all participants having benefited significantly in a number of ways.

4. Final program

First day. Thursday July 13, 2006

08.00 am – 08.30 am	Registration
08.30 am – 09.00 am	Opening. Prof. P. Pintado, UCLM Vice-Chancellor for International Relations, A. J. Conejo, B. Hobbs
09.00 am – 09.15 am	Questionnaire I. Chair B. Hobbs
09.15 am – 10.30 am	First plenary session: Toward a complete market design improving efficiency and reliability of electricity markets. R. O'Neill
10.30 am – 11.00 am	Coffee break: Sala Lorenzana
11.00 am – 01.00 pm	First session: Pricing and bidding strategies. Chair A. Bakirtzis
01.00 am – 03.00 pm	Lunch: Hotel Doña Carlota
03.00 pm – 05.00 pm	Second session: Market behavior and simulation. Chair F. D. Galiana
05.00 pm – 05.30 pm	Coffee break: Sala Lorenzana
05.30 pm – 07.30 pm	Third session: Congestion management and ancillary services. D. S. Kirschen
09.00 pm	Workshop dinner: Restaurante La Plata (near Rectorado building)

Second day. Friday July 14, 2006

09.00 am – 09.15 am	Questionnaire II. Chair B. Hobbs
09.15 am – 10.30 am	Second plenary session: How well can one measure market power in restructured electricity systems? Y. Smeers
10.30 am – 11.00 am	Coffee break: Sala Lorenzana
11.00 am – 01.00 pm	Fourth session: Operations and planning under uncertainty. Chair S.-E. Fleten
01.00 am – 03.00 pm	Lunch: Hotel Doña Carlota
03.00 pm – 05.00 pm	Fifth session: Equilibria models. Chair M. Shahidehpour
05.00 pm – 05.30 pm	Coffee break: Sala Lorenzana
05.30 pm – 07.30 pm	Structured discussion based on questionnaires. Follow-up research activities. Collaborative actions. Chairs B. Hobbs, A. J. Conejo
07.30 pm – 07.35 pm	Adjourn

5. Final list of participants (names and affiliations)

- 1 Florian Leuthold, Verbund Austrian Power Grid AG, Austria.
- 2 Yves Smeers, Univ. Catholique de Louvain, Belgium.
- 3 Luiz Barroso, PSR, Brazil.
- 4 Francisco D. Galiana, McGill Univ., Canada.
- 5 Jin Zhong, Univ. of Hong Kong, China.
- 6 Xiaohong Guan, Tsinghua Univ., China.
- 7 Rüdiger Shultz, Univ. Duisburg-Essen, Germany.
- 8 Anastasios Bakirtzis, Aristotle Univ. of Thessaloniki, Greece.
- 9 Bert Willems, European Univ. Institute, Italy.
- 10 Sebastiaan Hers, Energy Research Centre, The Netherlands.
- 11 Kurt Jörnsten, Norwegian School of Economics & Business Admin, Norway.
- 12 Stein-Erik Fleten, Norwegian Univ. of Science and Technology, Norway.
- 13 João Tomé Saraiva, INESC Porto, Portugal.
- 14 Yevgeniy Pogrebnyak, Institute for Complex Strategic Studies, Russia.
- 15 Antonio J. Conejo, Univ. Castilla – La Mancha, Spain.
- 16 José L. Martínez, Univ. Sevilla, Spain.
- 17 José Manuel Arroyo, Univ. Castilla – La Mancha, Spain.
- 18 Julián Barquín, Univ. P. Comillas, Spain.
- 19 Martin Kurzidem, ETH Zürich, Switzerland.
- 20 Daniel Kirschen, Univ. of Manchester, U. K.
- 21 Danny Ralph, Univ. of Cambridge, U. K.
- 22 Fernando S. Oliveira, Univ. of Warwick, U. K.
- 23 Ivana Kockar, Brunel Univ., U. K.
- 24 Karsten Neuhoff, Univ. of Cambridge, U. K.
- 25 Richard J. Green, Univ. of Birmingham, U. K.
- 26 Ben Hobbs, Johns Hopkins Univ., USA.
- 27 Mohammad Shahidehpour, Illinois Institute of Technology, USA.
- 28 Richard O'Neill, FERC, USA.
- 29 Shmuel Oren, Univ. of California at Berkeley, USA.

6. Statistic information on participants (age bracket, countries of origin, etc.)

1. Age bracket: –.
2. Countries of origin: Austria, Belgium, Brazil, Canada, China, Germany, Greece, Italy, The Netherlands, Norway, Portugal, Russia, Spain, Switzerland, U.K., and USA.
3. Continents of origin: America, Asia and Europe.
4. Male participants: 27, female participants: 2.
5. PhD participants: 29, non PhD participants: 1.