Electric Power Market Simulations Using Individuals as Agents

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Market Simulations Allow Us to Explore Market Strategies and Agent Adaptive Behavior

- Practice strategies that we learned through our research of electric power markets
- Examine and discuss the emergent behavior of individual agents and their market strategies
- Compare the behavior of Argonne agents to the observed evolution of the California and New England markets
- Gain insights into the methods that can be used to emulate market strategies of individual agents in the EMCAS model
Argonne Staff Act Out the Roles of Individual Agents in a Virtual Electric Power Market

- Demand agent
  - Consume electricity
  - Curtail demand when electricity becomes very expensive

- Generation agents
  - Own and operate virtual power plants
  - Submit power bids to the independent system operator (ISO)
  - Generate electricity to meet loads
  - Strive to maximize profits

- Independent system operator agent
  - Accept and reject generation agents’ bids
  - Dispatch operational units according to market rules
  - Post next-day weather and load forecasts
  - Compute and post market clearing prices
  - Post unit outages
Information Flow among the Agents is a Critical Feature of the Simulation Process

Collusion among Bidders Is Not Permitted
Simulation Bulletin Postings Are Very Similar to the Information Found on the California ISO Web Page

Generation Agents Use Bulletin Board Information to Formulate a Strategy for the Next Round of Bids

Future Forced Outages Are Unknown

There Are Weather Forecast Errors

Demand Forecasts Are Imperfect

Source: http://www.caiso.com/
### Bid Prices & Quantities

#### In EMCAS, Simulated Generation
Company Agents Submit Bids

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<th>Energy Sales Block ID</th>
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<th>Total Quality (MWh)</th>
<th>Quantity Remaining (MWh)</th>
<th>Heat Rate (BTU/kWh)</th>
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Based on Agent Bids, the ISO Determines Market Clearing Prices

Market Clearing Price

All Accepted Bids Are Paid the Market Clearing Price

This Method Is Used in Most Open Markets for Non-Contracted Energy

Accepted Supply Bids

Loads Served

Supply
Demand

Market Bids ($/MWh)

Demand (MWh)
Market Clearing Prices Varied Significantly among the Hours and Days of the Week

Two Large Low-Cost Units Were Out of Service

One Large Low-Cost Unit Was Out of Service

At Full Load, Marginal Production Costs Range from 17 to 49 $/MWh
Agents Adapted Their Strategies Over Time

By Day 5, the Bid Reached 300 $/MWh

This Strategy Provides for Very High Potential Benefits at a Very Small Cost

On Day 2, the Highest Bid Price Was 110 $/MWh
This Type of Gaming by Marketers Is Reportedly a Reality in California

- On July 9, 1998, a bid price of reserve power needed by the ISO was reported to be 1 $/MWh
- Suddenly, the $1 bid price shot up to $2500
- The bid price reportedly spiked suddenly to $5000 where it stayed for 3 hours before dropping back to $1
- Four days later a bid price rose to $9999 and it stayed at that level for 4 hours before it dropped to $0.01 in the next hour
- “All of us saw those numbers and realized … there was nothing to stop someone from bidding infinity,” said Jeffrey Tranen (former ISO staff member)
- It was evident from the first year of the market operation that players (agents) were probing for weak spots

¹Source: Sacramento Bee May 6, 2001
As Reserve Margins in California Shrink, On-peak Prices Rise above Marginal Costs

Some Analysts Are Speculating That Marketers in California Are Creating Artificial Shortages

1Source: California’s dysfunctional electricity market: policy lessons on market restructuring, Energy Policy, January 2001
Simulations That Use Individuals as Agents Can Provide Insights into How a Market Will Operate

- Agents learn about the behavior of the virtual market, and some will adapt their strategies to take advantage of the market rules and structure.

- Agents can probe the virtual market for flaws.

- In the future, market rules must be developed more carefully.

- Market structures and rules should be tested through model simulations to help uncover flaws.

- The California market might look different today if market designers had been able to perform rigorous market simulations in a virtual world before implementing rules in the real one.