



University of California at Berkeley

**Auctions are market mechanisms used to procure
or sell goods, award contracts, sell property
rights, allocate scarce resources etc.**

- Buy/sell items via internet (E-Bay, Yahoo,...)
- Procurement auctions (B2B)
- Direct and reverse B2C auctions (Yahoo, Priceline)
- Selling art or rare objects
- Treasury bonds sales
- Emission rights trading
- Spectrum auction (for PCS bands)
- Franchise Auctions
- DOD supply contracts
- Google IPO auction
- [Day ahead and hour ahead electricity procurement](#)
- [Ancillary services procurement](#)
- [Financial transmission rights auction \(FTRs\)](#)
- [Virtual diversification through capacity auctions \(Texas, Alberta, Europe\)](#)

Types of Auctions

- Single Dimension vs. Multi-dimension
 - Single item vs. Multi-item
 - Multi-item: Simultaneous vs. Combinatorial
- Single unit vs. Multi-unit
- One sided vs. Two-sided
- Sealed bid: Single round vs. Multi-round
 - First Price (pay or receive your bid)
 - Second Price (last accepted or first rejected uniform price)
- Open outcry
 - English (Ascending)
 - Dutch (Descending)
 - Anglo-Dutch (Ascending with sealed bid final round)

Auction Rules

- Definition of Tender (what is being auctioned)
- Form of Bid
- Opening rules
- Reservation prices if any (min or max bid)
- Activity and closing rules (in multi-round or open outcry, e.g. timing and increment of bids)
- Allocation and Settlement rules (who gets what for how much)

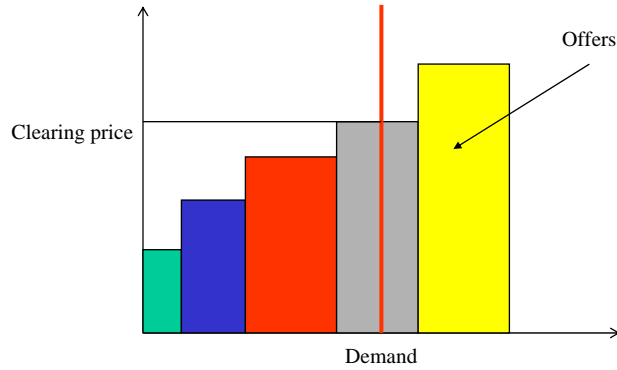
Auction Modeling and Analysis

- Perfect vs. Imperfect Information
- Private value, Common value, Affiliated values
- For Multi-item or Multi-unit: Independent values vs. Dependent values.
- Combinatorial auctions (set covering, bin packing, hierarchical, multi-attribute): Efficiency vs. incentive compatibility, activity rules, bid selection, settlement rules.

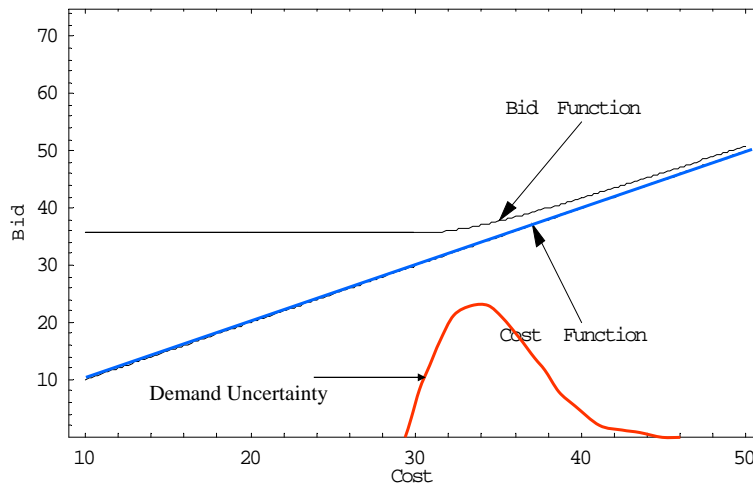
Second Price (uniform) Auctions – Vickery

- Bidders submit Bids/offers
- Best bid wins but pays/gets second best price
- For k identical items, k best bids win but pay/get $k+1^{\text{st}}$ price
- Bidders have incentive to reveal true value/cost
 - If value is V and you bid $V+a$ second highest bid may be $V+a/2$ so you may end up paying more than you value the item
 - If you bid $V-a$ someone else may bid $V-a/2$ (and pay $V-a$) so you lost an opportunity to get the item for $V-a/2$

Uniform Price Auction for a Continuous Commodity - Common procurement auction used in Electricity Market

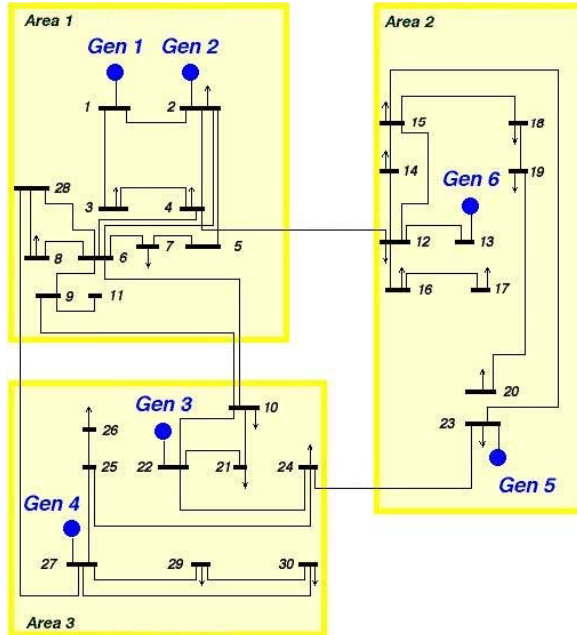


Theoretical Equilibrium Bid Function Under Pay as Bid with Demand Uncertainty



Revenue Equivalence : Expected payment for P-A-B and Uniform Price auctions are the same.

The PSerc 30-bus test network (PowerWeb)



The PSerc Pay as Bid Auction Experiment for Electricity Procurement

- Subjects (students) control generators with given marginal cost (per MWH) and capacity (MW)
- Each subject can submit multiple offers up to the capacity of its generator at any price they want
- Offers are sorted in increasing price and selected to meet uncertain demand (revealed at selection time)
- Each selected bid gets its offered price times the number of MW taken at that price
- Subject remuneration is based on the net profit they accumulate in the experiment.

Experimental Results for Pay as Bid Auction

Examples of Multi-dimensional and Multi-product Auctions

- Bids for project specifying price, completion time, tardiness penalties, etc.
- Bids for logging rights specifying price for each type of wood
- Franchise bidding specifying fixed payment and price per unit of commodity
- Bids for electricity supply specifying energy price, startup cost, ramp rate, minimum load, scheduling constraints.
- QF electricity auction specifying capacity price per MW installed and energy price per MWh supplied
- Ancillary services procurement auctions (AGC, Spinning reserves, Nonspinning reserves, Replacement reserves)

Winner Determination and Settlements in Multi-Item and Multi dimensional Auctions

- Bidders submit single or multidimensional bids for combinations of items with logical side constraints (either/or, if then, etc.)
- A combinatorial optimization algorithm selects winning bids so as to optimize some objective function (max social welfare, max revenue, etc.) and determines payments by winning bids (not to exceed bid price)
- Settlement rules set to induce efficient allocation

Simultaneous Ascending Multi-round Multi-Item Auction (proposed but never implemented at PX)

- Bidders submit simultaneous separate bids for each item
- After each round winning bids announced and bidders can revise their bids upward (subject to activity rules) so as to take into considerations the new information and their preferences for combinations of items
- Final round (based on some stopping rule) determines the winners (highest bids) and payments
- Revisions controlled by activity rules (e.g. No withdrawal in final round, min % or sum of increase in each bid or total to keep bids alive, all bids must be entered at start)
- Purpose of activity rules to induce price discovery, speed up convergence, prevent bidders from sitting on sideline and jump in in final round, prevent collusion.

Hierarchical Products Auctions for Electricity Reserves (CAISO)

Service	Description
AGC/Regulation (up / down)	Generator's equipment that provides regulation service
Spinning Reserve	Unloaded capacity synchronized to the grid that will ramp up in 10 minutes
Non-Spinning Reserve	Not synchronized to the grid but can ramp up in 10 minutes
Replacement Reserve	A quantity of capacity that will ramp up within 60 minutes

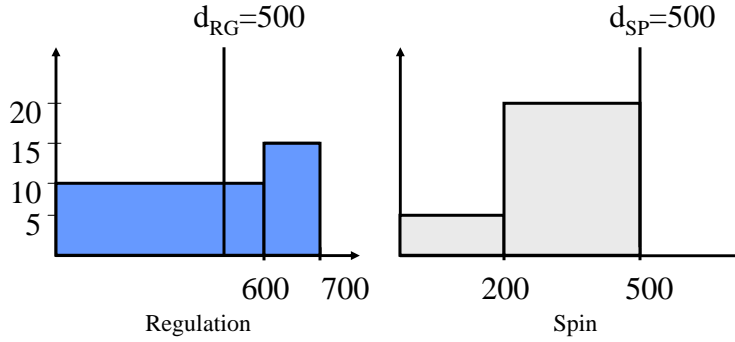
Procurement Auction Features

- Key feature - downward substitutability
- Basic Approaches:
 - Sequential auctions (substitution through rebidding)
 - Auction order: Regulation, Spin, Nonspin, Replacement
 - Offer prices: Single, Simultaneous multiple, Sequential
 - Uniform market clearing price in each auction
 - Simultaneous auctions (substitution by ISO)
 - Objective function: Min social cost or Min procurement cost
 - Settlement rules: MCP based on offer type, MCP based on use, Marginal value (shadow price), Pay as Bid.

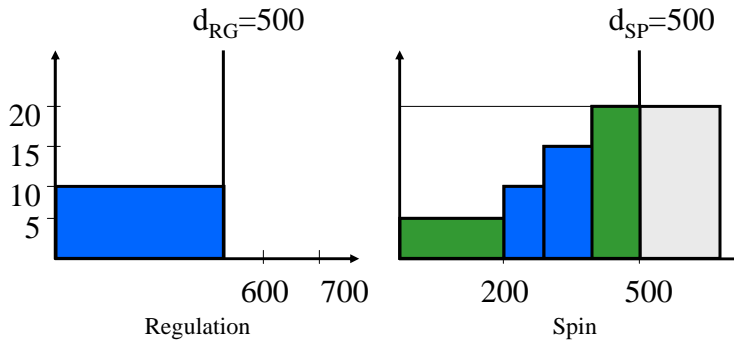
Reserves Auction - an example

- Two type example

Regulation 600 MW at \$10 /MW 100 MW at \$15 /MW
 Spin 200 MW at \$ 5 /MW 300 MW at \$20 /MW



Sequential Auction



Total Procurement Cost = $500 \cdot 10 + 500 \cdot 20$
 = \$15,000

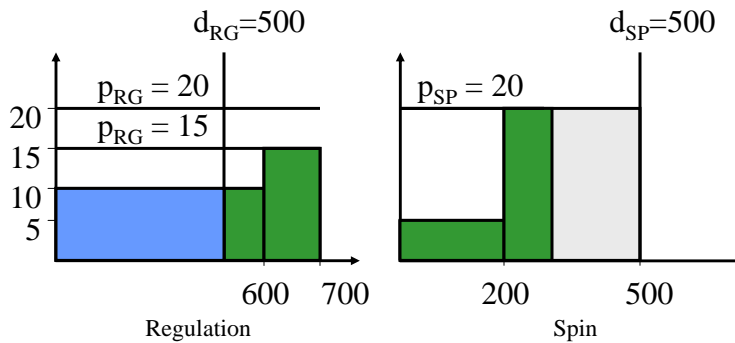
Revealed Social Cost = \$10,500

Design Options for Simultaneous Reserves Auction

- The objective function used for bid selection
 - Minimum social cost (as bid)
 - Minimum procurement cost
- Settlement rule
 - Pay uniform price based on bid type (demand substitution)
 - Pay uniform price based on usage (product substitution)
 - Pay highest clearing price for which bid is eligible [Marginal Value]
 - Pay as bid
- Pricing of the products to buyers of ancillary services
 - Set product price to highest accepted bid of type
 - Set product price to highest price paid to meet product demand
 - Marginal value pricing

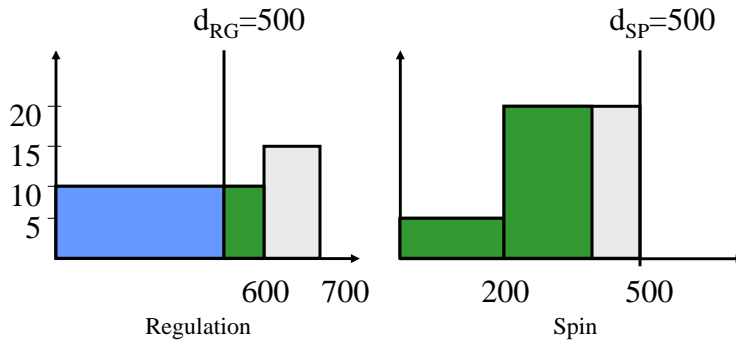
New York, California

Simultaneous Auction Minimum Social Cost Selection



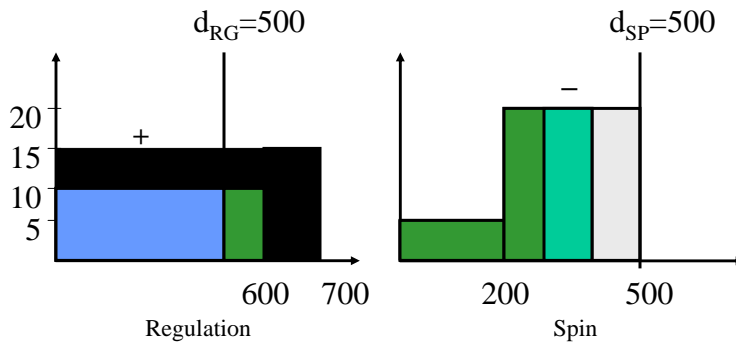
Settlement Rule	Procurement Cost (\$)	
Highest Accepted Bid	16,500	Misrepresent quality
Marginal Value	20,000	Incentive compatible
Pay as Bid	10,500 (Soc. Cost)	Misrepresent cost

Simultaneous Auction Min Procurement Cost Selection



Procurement Cost (\$)	Social Cost (\$)
14,000	11,000

Simultaneous Auction Min Procurement Cost (contd.)



Saves (black): 4500
 Spends (red): 2000
 Difference: 2500

Price Reversals in California Under Rational Buyer Procurement

- Price reversals have been reported in the CAISO ancillary service market under the rational buyer auction
- On March 20, 2000 in HE 19, there was a spike in the Replacement Reserve price. The following are published prices for NP15:

Reg-Up: P1 = 18.44 \$/MW

Spin: P2 = 35.97 \$/MW

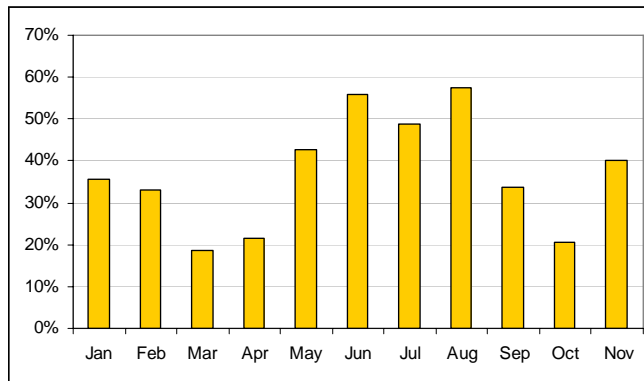
Non-Spin: P3 = 18.00 \$/MW

Replacement: P4 = 198.98 \$/MW

Note that $P4 > P3, P2, P1$. Also $P2 > P1$.

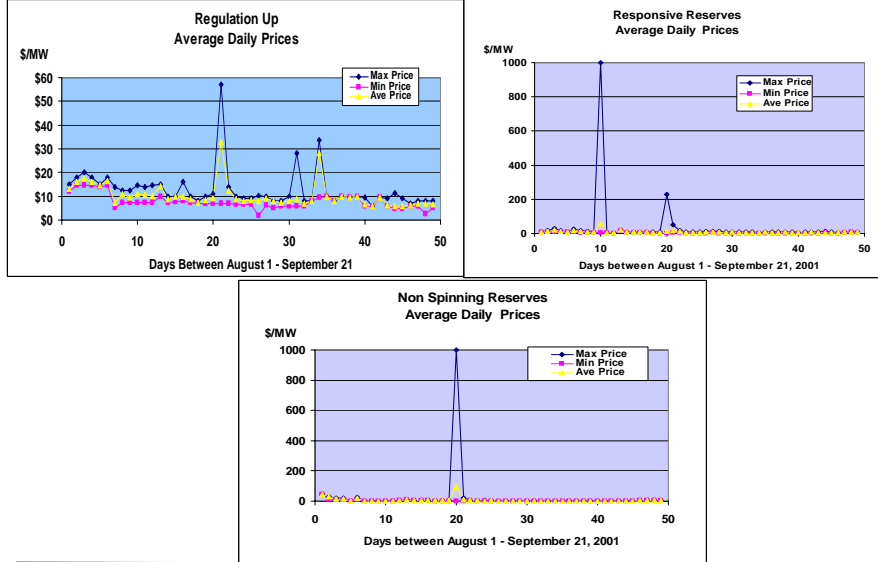
- A similar pattern in AS prices was observed on Feb 29, 2000 in HE18 when replacement reserve prices were 122\$/MW

NP15 A/S Price Reversal Frequency in 2000



If Reg = 4, Spin = 3, Non-spin = 2, Repl. Res = 1,
a price reversal occurs if $Price_j > Price_i$ for $i < j$ where i, j denote the type of A/S

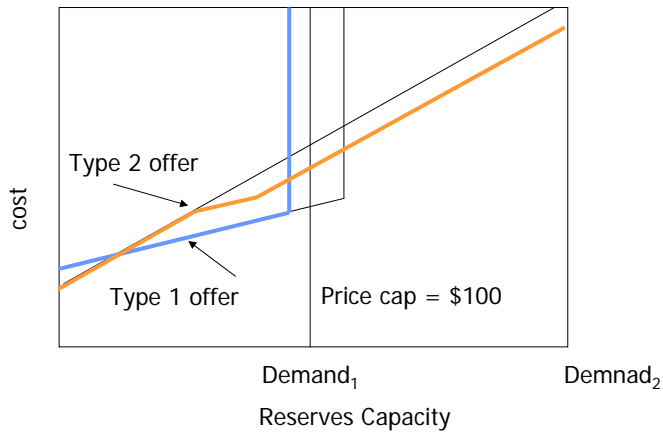
Price Reversals in ERCOT AS Markets Under Sequential Auction



Shmuel Oren

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Rational Buyer Meets Rational Seller



Shmuel Oren

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Auction Design=Market Engineering

Math

$$\begin{aligned} \nabla \times \vec{E} &= -\frac{\partial \vec{B}}{\partial t} \\ \nabla \cdot \vec{D} &= \rho \\ \nabla \times \vec{H} &= \frac{\partial \vec{D}}{\partial t} + \vec{J} \\ \nabla \cdot \vec{H} &= 0 \end{aligned}$$



Lab

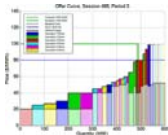
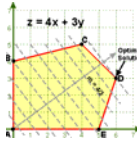


Physics



Power Systems Engineering

OR



Experiments



Economics



Market Engineering

Questions?

