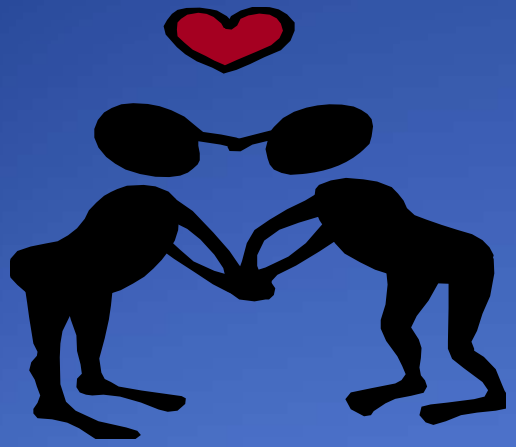
Idiosyncratic assets interconnected markets and arbitrage



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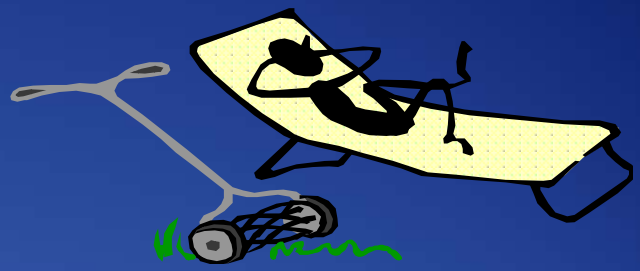
March 7-8, 2013

The views presented are the personal views of the authors and not the Federal Energy Regulatory Commission or any of its Commissioners

Market history



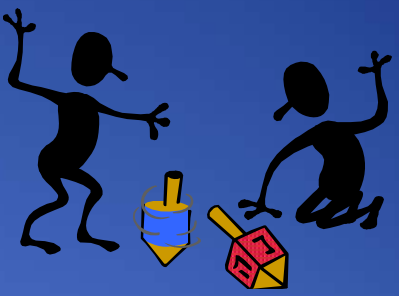
- Historically: pre-1990
  - Risks are borne by consumers via their agents (regulators)
  - Weak trading
  - cost-of-service pricing
- Markets: post 1990
  - Market-based rates
  - Risks shared by voluntary contracts
  - Increased trading

Idiosyncratic Bulk Power System Assets

- Sunk costs/Asset specificity
  - 10 years in planning
  - 30-50 year life
  - Location
- Risks:
  - financial,
  - Technical
  - Environmental
  - Market
  - regulatory

History of Colored Swans twenty years ago today

- White Swans (known knowns)
  - Nukes: Half century of 300% cost overruns
  - Natural gas: Half century of price volatility
- Gray Swans (unknown knowns)
  - Climate change: what is the cheapest fix?
  - Health: Canceled and retired coal plants
  - Lower Demand: Canceled transmission assets
- Black Swans (unknown unknowns: outliers)
  - Shale gas paradigm shift:
    - bridge fuel
    - The bridge is getting longer

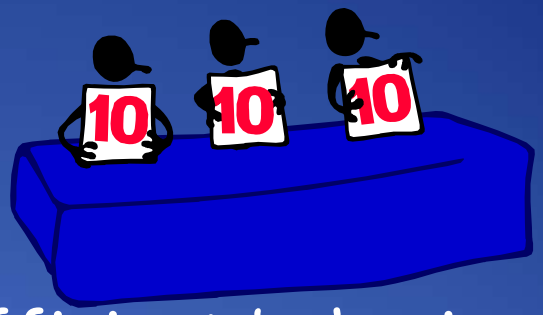


Investment decisions to products

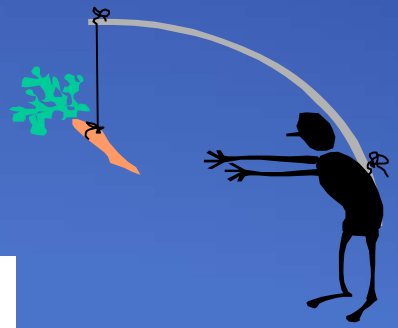
- Start with idiosyncratic assets and contracts
  - generation: nuke, coal, natural gas, wind, solar
  - Load: industrial, commercial and residential
  - Transmission assets
- Real power is a mostly homogenous product indistinguishable from who makes it
- other products: reactive power, ramp rate, and capacity

Principles of ISO Market Design

- Maximize benefits to society
  - Demand (value) functions minus
  - Supply (cost) functions



- Distribution of benefits to incent efficient behavior
  - LMP
  - Uplift allocation
  - Capacity prices



- Mitigate market power
  - Bid marginal costs
  - Bid marginal value

ISO Auction Markets

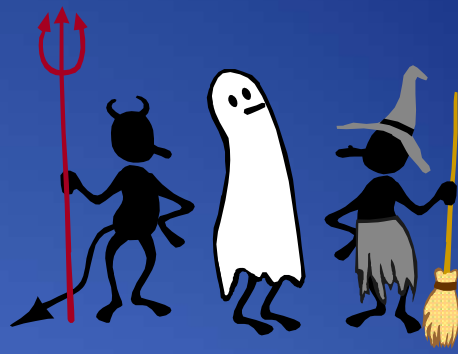
- Market Design for all ISOs
  - Transmission rights
  - day-ahead unit-commitment market
  - Residual unit commitment
  - Real-time market
- Capacity markets: 3 of 7 ISO markets
  - Price-responsive demand/Scarcity pricing
  - Call option for advance planning
- day-ahead and real-time market risk changes from
  - Not having enough power or over contracting to
  - Price volatility, but very liquid ISO markets
  - Clean up the physical infeasibilities from bilateral trading

The ISO Day-ahead and Real-time Markets

- LMP is a public uniform price for homogeneous product
  - Quantities are individual (private)
  - almost clears at the 'law of one price'
  - 95% of revenue transfers are at the LMPs
- Market Uplift is a private non-uniform price for non-homogeneous product
  - start-up, reactive power, loss errors
  - Quantities are semi-public (cannot directly assign costs)
  - 5% of revenue transfers; often peanut buttered
  - Need greater differentiation and better cost allocation

ISO Market Approximations

- Linear 'DC' model for non-convex AC flows
  - Linear model employs estimated losses
  - No reactive power; fixed voltages
  - Non-optimal topology (network)
- Markets have different time intervals
  - Financial transmission right: month or more
  - day-ahead market: hourly
  - Real-time market: 5 minute dispatch
- What is the cost of the approximations?



Real-time market

- the non-convex physics presents arbitrage
- Can't fool mother nature
- Approximations create
  - Greater uplift
  - inefficient LMPs
  - Greater arbitrage opportunities
- Signal for better software and market design

Losses

- Currently estimated because the market model is an approximation
- day-ahead market with financial market participants
  - discover errors and arbitrage
  - better the price signal and dispatch
  - lower uplift
  - Make money
- Without financial market participants
  - incorrect the price signal
  - greater uplift

Time interval differences

- Financial transmission right (maybe weekly)
  - Monthly intervals
  - Outage for one week
  - What is the best network?
- day-ahead market
  - Hourly (maybe 15 minutes)
  - No congestion in hour interval
- Real-time market
  - Congestion in some 5 minute interval
  - 5 minute pricing
- Can we shorten the intervals?

Seams

- collision of the ISO markets and contract path markets
- Arbitrage opportunities
- Should we price loop flow?
- Is ACE yesterday's concept?
- ACE may have been good for
  - Voluntary reliability
  - 100+ control areas

Financial market participants

- Traditional risk management
  - Liquidity: the ability to trade quickly at the efficient price
  - Trade in forward bilateral markets
  - Finance projects
- ISO markets are very liquid
- Arbitrage in ISO markets
  - Check market power in the forward markets
  - Move prices to expected price in the real-time market
- Arbitrage design flaws: Incent fixes?
  - Bad loss estimates: Lower uplift
  - Time intervals
  - Contract path and TLRs

continuous trading via standard bilateral contracts

- Standardized 'bilateral' markets for faster trading
  - WSPP standardized contract
  - EEI Master Contract
  - Provide credit provisions and standard product definitions
  - basic negotiable elements, e.g., price, quantity, location, and duration
- Public exchanges: ICE, NYMEX, Nodal
  - Actual trades
  - Published prices
  - Published quantities
- Indexed pricing

combination companies

- Using the regulated utility as a source of free capital has a long tradition

- Regulated utilities are generally very risk averse with cost pass-throughs
  - Look for a published 'price' that its regulator agrees to
  - Mark bilaterals to 'market' (public exchange)
  - Thin trading on public exchange is ripe for manipulation

ICE

Power Delivered on Thurs., Feb. 21, 2013

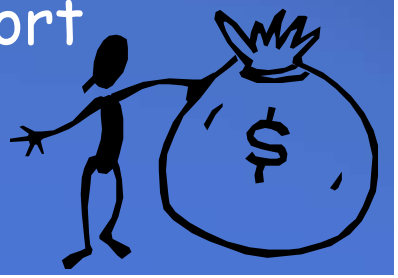
Hub	High	Low	Wtd Avg Index	No. of Trades	No. of Companies
Mona Off-Peak	$25	$25	$25	1	2
NYISO G Peak	$105	$105	$105	1	2
Four Corners Peak	$30	$30	$30	2	4
Indiana Hub RT Peak	$34	$34	$34	2	4
Pinnacle 230 Peak	$33	$32	$32	3	3
COB Peak	$32	$31	$32	4	6
Mead Peak	$33	$32	$32	6	9
SP15 DA LMP Off-Peak	$35	$35	$35	7	7
Nepool MH LMP Peak	$137	$130	$133	33	17
Palo Verde Peak	$32	$30	$31	37	17
SP15 DA LMP Peak	$46	$44	$45	41	17
PJM WH Real Time Peak	$44	$42	$43	68	33
Mid C Peak	$30	$28	$29	159	20

Neo-classic financial market participant theory

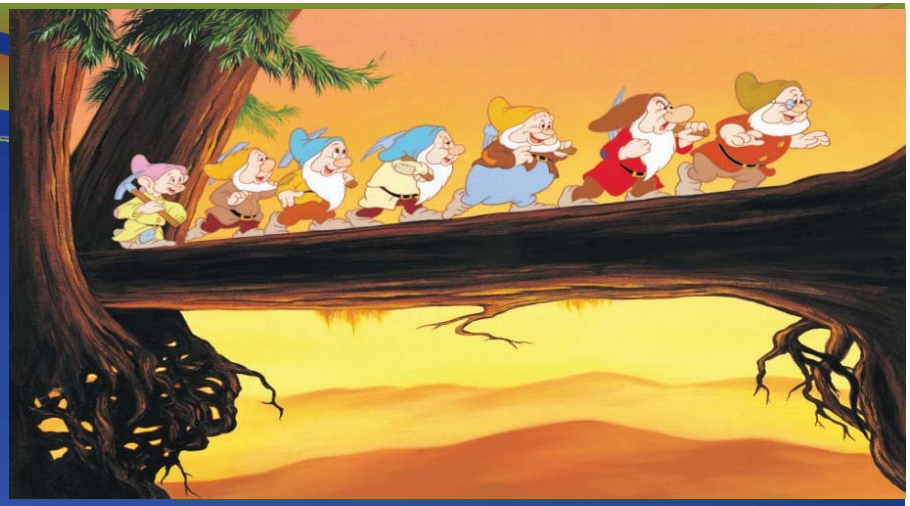
- Complete markets
- Easy entry and exit
- No transaction costs
- Common knowledge of probabilities
- Risk neutral
- Infinite capital
- Complete liquid markets
- Make no profit

transactions cost financial market participant model

- Incomplete markets
- transaction costs cause market frictions
- Rogue traders
- Common knowledge of historic information
  - Must exact useful information
  - Short-term asymmetric information
- Take advantage of asymmetric information
  - While it lasts
- correct market design flaws
- Must have contingent capital collateral to support trading eg, margin calls



Enron et al



- 1990: regulated companies
- Market-based rates for natural gas
- Start a trading arm
  - Frogs becomes Wall Street princes
  - one eyed giants in the valley of the blind
  - Under capitalize trading
- 2001: Princes become frogs
  - Bankrupt or almost bankrupt
- 2008: Constellation (la deuxième partie?)

What are the lessons?

Have we learned the lessons?