Local Market Power Mitigation (LMPM) under Locational Marginal Pricing (LMP)

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Outline of Talk

- Local Market Power Problem
  - What is it? Why does it exist?
  - Can locational pricing solve this problem?
- Goals of local market power mitigation
- Analysis of PJM local market power mitigation mechanism
- Proposed LMPM mechanism
  - Properties of proposed LMPM mechanism
- Financial Transmission Right (FTR) allocation and local market power mitigation
  - Efficient FTR allocation mechanism

Origins of Local Market Power

- US transmission network was built for former vertically integrated utility regime
  - Built to take advantage of fact that both transmission and local generation can each be used to meet an annual local energy need
    - Captures economies of scope between transmission and generation
  - Integrated resource planning by vertically-integrated utility considers both local generation and transmission to find least-cost solution to serve sustained load growth
  - Transmission capacity across control areas of vertically-integrated monopolists built for engineering reliability
    - Sufficient transmission capacity so imports could be used to manage large temporary outages within control area
    - Few examples where transmission capacity was built to facilitate significant across-control-area electricity trade--California/Oregon

Origins of Local Market Power

- Wholesale market has independent system operator (ISO) to allocate transmission network capacity
  - Owner of local generation financially independent of ISO
    - In both short-term and long-term, ISO cannot take advantage of economies to scope between transmission and generation that current transmission network was designed to utilize
    - Local generators have strong incentive to cause transmission constraints under ISO regime
      - Raise local prices for energy (either by withholding capacity or bidding high prices) to cause congestion under ISO regime
  - State public utilities commissions (PUCs) sold off generation assets of former vertically integrated monopolists in bundles of units located in small geographic areas
    - This exacerbated extent of local market power problems

Origins of Local Market Power

- Because of the way state regulators price retail electricity hourly wholesale demand is virtually inelastic with respect to wholesale price electricity prices
  - Little deployment of interval metering technology necessary to support active end-user participation in wholesale market
- Transmission network configuration, geographic distribution of wholesale electricity demand, concentration in local generation ownership, and production decisions of other generation units combine to create system conditions when a single firm may be only market participant able to meet a given local energy need
  - This firm is monopolist facing completely inelastic demand
  - No limit to price it can bid to supply this local energy need

Local Market Power Problem

- Congestion management or locational-pricing scheme does not solve locational market power problem
  - Given a geographic distribution of demand, configuration of transmission network, and production decisions of other units in this network, a firm is local monopolist for certain quantity of energy regardless of congestion management/locational pricing scheme
  - No limit to what firm can charge for amount of energy over which it is a local monopolist regardless of locational pricing scheme
- ISO must have the ability to mitigate firms with local market power
  - All Eastern ISO's have ability to mitigate bids of any market participant the ISO perceives as having local market power
    - Different methods for determining whether a supplier has local market power
  - PJM Local Market Power Mitigation (LMPM) mechanism is most stringent of those currently in place in US
    - Major reason for "superior performance" of PJM market
  - Not until after June 2001 did California have an ex ante LMPM mechanism
    - Previously paid non-RMR suppliers with local market power as-bid

Local Market Power Problem

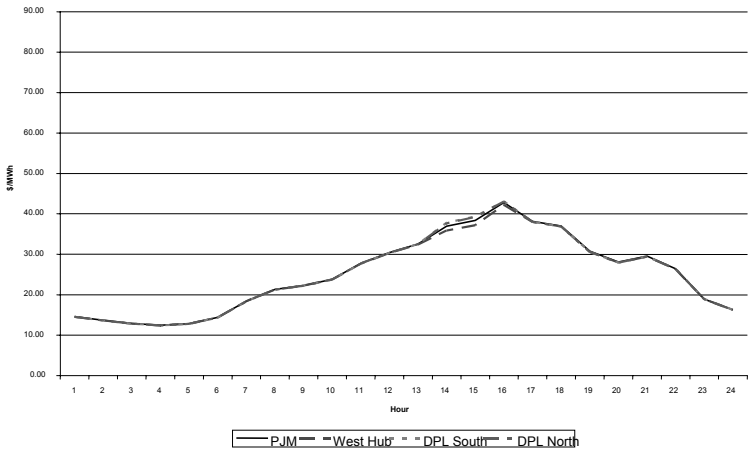
- Frequency and magnitude of congestion should be independent of ownership structure of generation units
  - If no supplier has local market power
- Congestion occurs because it is very profitable for certain market participants
  - Want to pay suppliers for higher cost to produce energy at certain locations in network
  - Promise to do so may give suppliers opportunity to exploit local market power to raise prices at certain locations in network
  - Suppliers may take actions which are unilaterally profitable even though these actions may degrade ability of this supplier and other suppliers to deliver energy to final load
- Provide example from PJM market that shows transmission congestion depends crucially on ownership structure of generation units and method used to manage congestion

Supplier Incentives Determines Frequency and Amount of Congestion in PJM

- Regime 1—Vertically integrated (VI) utility that owns local generation and transmission network had fixed price contract with retailer in DPL South--6/1/98 to 7/22/99
  - Strong incentive to limit locational price differences
- Regime 2—Fixed price contract with retailer in DPL South ended—7/23/99 to 6/24/01
  - Strong incentive to increase locational price differences because this increases value of VI utility's local generation holdings and Congestion Revenue Right (CRR) holdings
- Regime 3—Large retailer divested large amount of DPL South capacity to merchant generation owner—6/23/01 to 6/20/03
  - Strong incentive to increase locational price differences between both DPL South (merchant supplier) and DPL North (large retailer) and other PJM locations

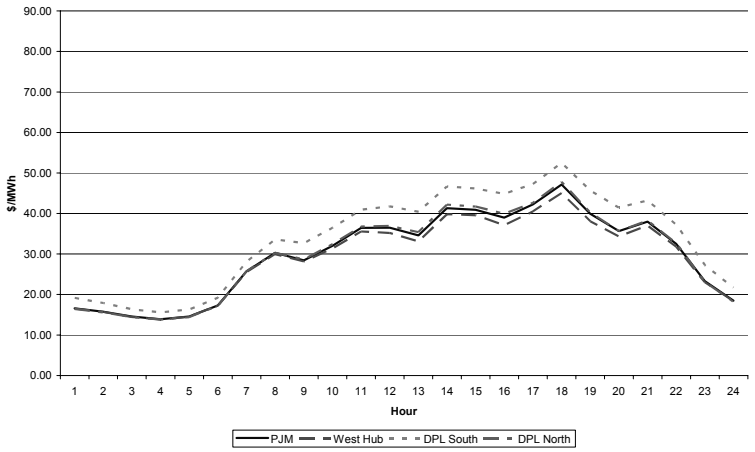
Incentives in Action in PJM Market

Real-Time Prices Average
Regime 1: 06/1/98 - 07/22/99

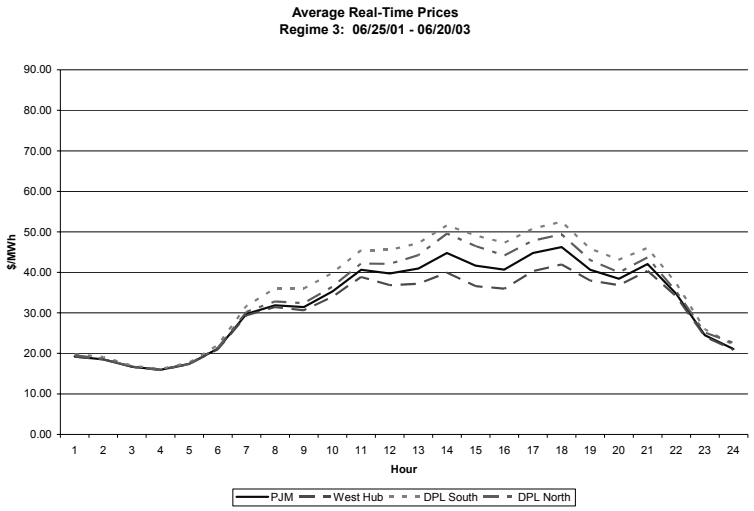


Incentives in Action in PJM Market

Average Real-Time Prices
Regime 2: 07/23/99 - 06/24/01



Incentives in Action in PJM Market



Local Market Power Mitigation (LMPM)

- Rationale for prospective LMPM mechanism
  - Virtually any unit in the control area can possess substantial local market power
    - Depending on system conditions
  - These system conditions create insufficient competition for local energy
  - Because of insufficient competition for local energy need, market mechanisms cannot be relied upon to set price this supplier receives
- Important to distinguish between services that can be most efficiently provided through a market mechanism and those that can be most efficiently provided through a regulatory process
  - Little reason to allow a market mechanism to set the price paid for an inelastically demanded monopoly service
- Transmission network configuration and generation ownership shares influence the market versus regulatory pricing decision
  - Greater divestiture and more transmission capacity
    - Less frequent local market power mitigation
  - LMPM mechanism is necessary in all markets
    - Not cost-effective to build enough transmission to eliminate need for LMPM

Goal of LMPM

- Competition-enhancing LMPM mechanism
  - Should not be more financially attractive that participating in market
- Prevent suppliers cross-subsidizing market participation with revenues from regulated services
  - Classic problem in regulatory economics
- Prospective mechanism that applies to all generation units in control area
  - Virtually impossible to predict which units will possess local market power
- Eliminate incentive of supplier to leverage local market power to all units owned
  - Most common form of cross-subsidy problem
- Eliminate incentive of supplier to increase size of generation portfolios
  - Reduces magnitude of local market power problem

PJM Solution to Local Market Power

- If PJM ISO determines that a generation unit possesses local market power then its bids are mitigated to one of three levels
  - Variable operating costs plus a 10% adder
  - An average of accepted bids from that unit when it was known not to possess local market power
  - A level mutually agreed upon by ISO and market participant
- First bid mitigation method is by far most common
- PJM ISO determines a unit possesses local market power sufficient to require mitigation by first examining three major transmission inter-changes in control area
  - Bids used to manage congestion across inter-changes cannot be mitigated
  - If bid from a unit is taken out of merit order on one side of an interchange, then this bid is mitigated

PJM Solution to Local Market Power

- PJM defines a bid to be out-of-merit order in the geographic area defined by one side of the inter-change if
  - Lower priced bids in this geographic area cannot be taken because of transmission constraints
  - This creates “must-run” situation for the unit that can supply energy, so that it is local monopolist for required quantity of energy
- PJM LMP mechanism is run with mitigated bid in place of actual bid that unit submits
  - Mitigated bid can set market-clearing price
- For this reason, PJM mechanism can create incentives for firm to leverage local market power to system-wide market power
  - Use high-priced mitigated bid to set prices for all other units
- PJM mechanism provides incentives for firms to become large
  - Use local market power of one unit to raise prices a larger number of units receive

Potential Inefficiencies in PJM Solution to Local Market Power

- Portfolio generators can leverage local market power to system-wide market power under PJM mechanism
- Suppose that regardless of actions of all other firms, local generator must supply 100 MWh of energy at mitigated level of $50/MWh
  - All generators know that regardless of how they bid or schedule their units this $50/MWh bid will be accepted and it can set the market price
  - This $50/MWh bid can set floor on the bids they will submit, regardless of their variable cost of production
- If their variable cost of production was $25/MWh and they did not know a $50/MWh mitigated bid would be accepted and can set price (no matter what they bid) and there was effective competition, these firms would bid close to $25/MWh

Designing an LMPM Mechanism

- Three general steps
  - Specify a method for determining whether a supplier possesses local market power worthy of mitigation
    - Mitigation is costly in terms of market efficiency
  - Specify a method for compensating mitigated supplier
  - Specify conditions under which mitigated supplier can participate in market
- Because all suppliers can posses local market power under some system conditions
  - LMPM mechanism is promise not to mitigate some high bids, but to mitigate others, depending on system conditions
  - Rely on market mechanisms to limit prices where competition is possible
  - Rely on regulatory mechanism where competition is not possible
- Example from PJM
  - $1000/MWh bid “in merit” is accepted
    - Across one of three competitive inter-changes
  - $1000/MWh bid “out of merit” is mitigated
    - Across one of non-competitive inter-changes
- Impossible to mitigate all market power
  - Imply existence of perfect regulatory process

Alternative LMPM Mechanism

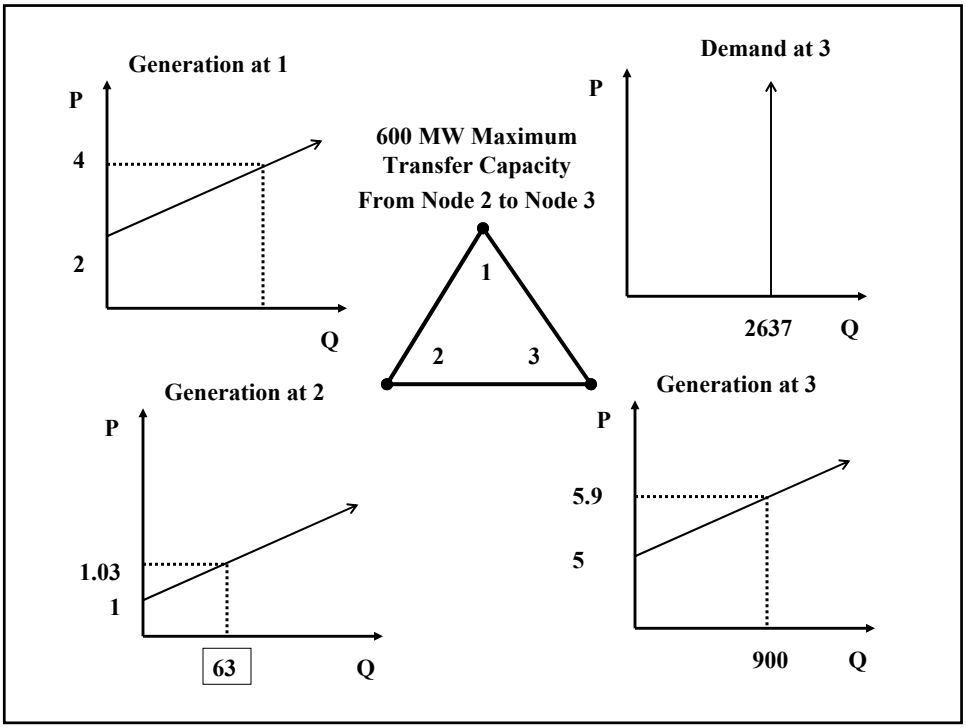
- If firm is determined to be must-run, this quantity of energy entered into LMP process as a price-taker
  - Firm is must-run for pivotal capacity
  - Firm with local market power has option
    - Receive variable cost for must-run energy
    - Receive market-clearing price at that location
- This mechanism eliminates floor on bids by other units because mitigated bid cannot set market-clearing price

Solution to Local Market Power

- Because must-run unit is providing service as a regulated local monopolist, it should not be able to influence market price with its mitigated bids
  - Regulated monopoly service “cost” should not set a market price
  - Limits opportunities for cross-subsidies from regulated to market services
- All LMP prices should be set by bids submitted by generators that do not possess local market power
- Competitive (not regulated monopoly cost-based) bids set LMP prices at all locations
  - Major motivation for re-structuring was to have market forces not cost-of-service regulation set prices
- Because generators know that must-run energy bids (even if they are mitigated) will not be allowed to influence market prices, they will have less incentive to withhold energy from local units to have them declared out of merit or must-run

Solution to Local Market Power

- Paying suppliers their “costs” or allowing regulated “costs” to set market price creates incentives for suppliers to raise their costs
- Clear separation between pricing of regulated service and competitively provided services limits incentives to increase costs
- Excluding pivotal quantity of energy from price-setting process prevents firms from leveraging local market power to other units
- Suppliers can bid market prices for any output beyond pivotal quantity
- Pivotal quantity definition of local market power can be solved using full network model
  - Minimize total quantity of pivotal MWs subject to all network constraints and total supply equals total demand
- Only pivotal quantity of energy subject to mitigation
  - Supplier free to submit any bid for remaining capacity (subject to market rules)
- Limit amount of capacity mitigated to monopoly facing inelastic demand
- Do not allow mitigated capacity to interfere with market pricing mechanism



3-Node Example of Pivotal Supplier

- 2637 MW load at node 3
- 600 MW transfer capacity from node 2 to node 3
- Network constraints on Locational Marginal Pricing (LMP) algorithm (respect loop flow constraints)
  - 1/3 q(1) + 2/3 q(2) $\leq$ 600 [Transfer capacity from node 2 to node 3]
  - q(1) + q(2) + q(3) = 2637 [Supply equals demand]
- Network constraints imply that at least 837 MW must be supplied at node 3
  - Multiplying first constraint by 3 yields--q(1) + 2 q(2) $\leq$ 1800
  - 2637 – 1800 = 837
  - 837 is pivotal quantity at node 3
  - How much each supplier must bid as price-taker depends on ownership of capacity at node 3
    - More owners less capacity from any given supplier is mitigated
  - The more energy is supplied by the generator at node 2, the greater is the pivotal quantity at node 3

LMP Pricing Algorithm

- Minimize as-bid costs subject to network constraints
  - Assume generators at each node bid their marginal cost curve
  - Let C(i,(q(i)) equal the total cost of supplying q(i) at node i
- LMP pricing algorithm solves
- Minimize C(1,q(1)) + C(2,q(2)) + C(3,q(3)) subject to
  - 1/3 q(1) + 2/3 q(2) $\leq$ 600
  - q(1) + q(2) + q(3) = 2637
  - q(3) $\geq$ 837

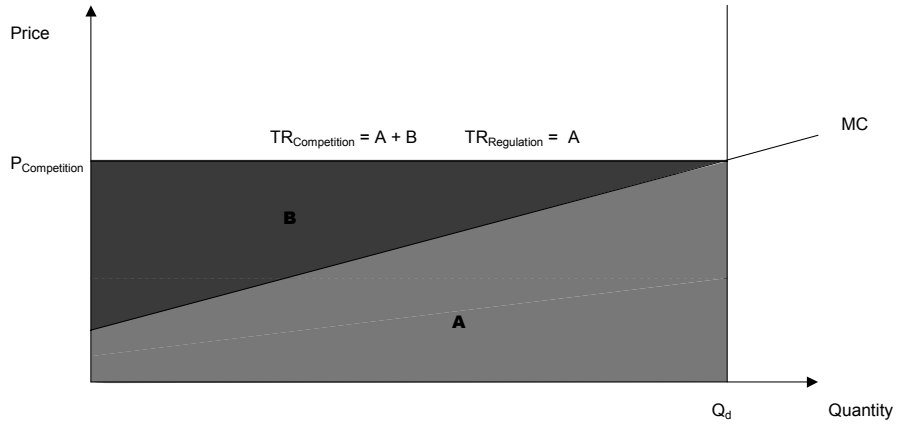
Local Market Power Mitigation Mechanism

- Pivotal quantity of energy is subject to mitigation
  - Only pivotal quantity from unit is subject to mitigation
- Bids from pivotal quantity are excluded from LMP pricing mechanism
- Pivotal quantity of energy paid
  - Variable cost
  - LMP at generator's location
- LMP pricing algorithm with mitigation solves
- Minimize C(1,q(1)) + C(2,q(2)) + [C(3,(q(3))-C(3,837))] subject to
  - 1/3 q(1) + 2/3 q(2) $\leq$ 600
  - q(1) + q(2) + q(3) = 2637
  - q(3) $\geq$ 837

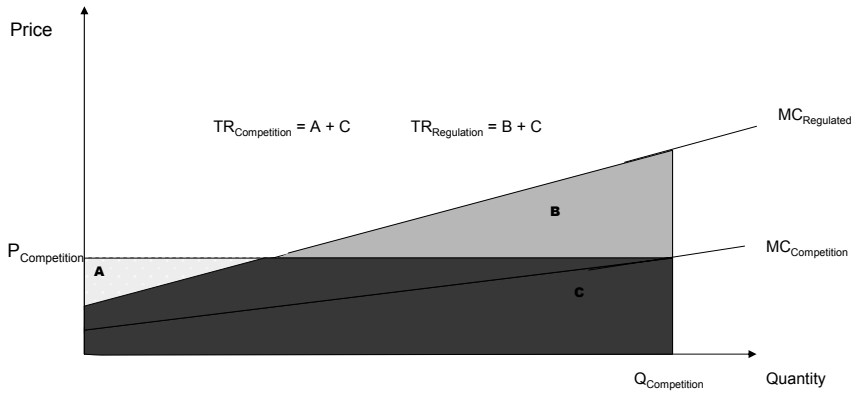
Regulation versus Competition

- Using regulated costs to set market prices is a very inefficient form of cost-of-service regulation
  - Give up on major source of benefits from competition
- When minimum cost of providing service is known, little reason to run a market for service
  - Cost-of-service regulation can be used to set price
- When minimum cost of providing service is unknown, run a market to determine this cost
  - Markets provide strong incentives for minimum cost production
  - Not necessarily strong incentives to pass-on lower costs in lower prices—unless market is competitive
- Minimize amount of regulated price-setting
  - Rely on market mechanisms wherever possible
  - Regulation is necessarily imperfect

Pricing Under Competition Versus Regulation



Pricing Under Competition versus Regulation



Firm Transmission Rights (FTRs) and Local Market Power

- How FTRs are allocated can also impact ability of firms owning generation to exercise local market power
  - If own a substantial amount of FTRs it may be more profitable to cause rather than relieve congestion because of FTR revenues
- This logic argues in favor of allocating FTRs to load serving entities (LSEs) rather than auctioning them to highest bidder
  - Highest bidder is most likely to be generation unit owners, rather than LSE, because generation unit owners have more flexibility to use FTRs
- Two uses of FTRs
  - Passively use them to hedge congestion risk
  - Actively use them to earn congestion revenues
- Second use requires ability to alter congestion charges
  - LSE's real-time demand is inflexible, so they only have first use for FTRs
- Conclusion--FTR allocation process should net out some fraction of generation ownership or long-term commitments to generation in LSE's service area in determining FTR allocation

Firm Transmission Rights (FTRs) and Local Market Power

- Allocation mechanism would treat LSE with peak load of 1000 MW and 200 MW of generation capacity in its service area different from LSE with peak load of 1000 MW that owns no generation capacity in service area
- Fraction of LSE local generation capacity or long-term commitments that are netted out of load obligations should
  - Compensate LSEs for local generation
  - Eliminate incentive to use local generation to earn from profits from causing congestion
- FTR allocation mechanism should not provide incentives for LSEs to increase generation capacity in their own service area
  - Proposed mechanism eliminates this incentive
- Purpose of FTRs is to provide insurance against congestion charge risk-->Firms should not expect to earn profits from FTRs
- Even transmission network ownership can allow firms to use FTR ownership to increase profits

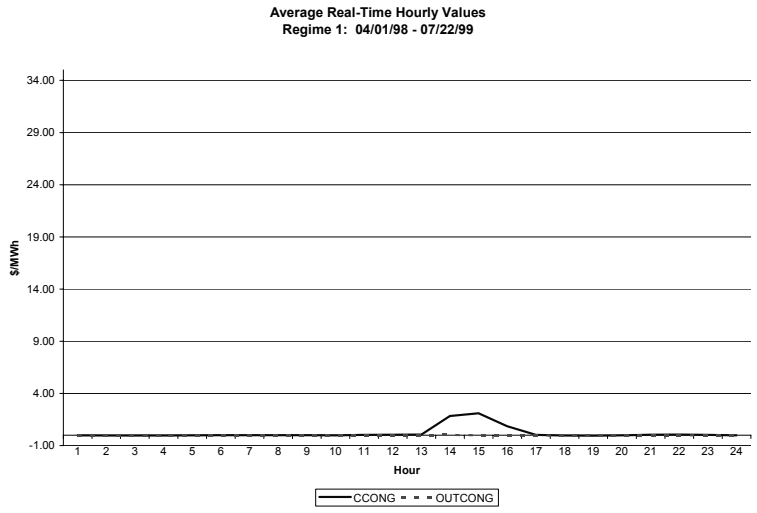
Using CRRs to Profit From Transmission Outages in PJM Market

- Let TRANOUT(h,d,y) = indicator that is equal to one if there is a transmission outage in hour h of day d in year y
- PD(DPL Zone, h,d,y) = real-time DPL Zone price in hour h or day d in year y
- PD(WH,h,d,y)) = real-time Western Hub price in hour h of day d in year y
- OUTCONG(h,d,y) = TRANOUT(h,d,y)*(PD(DPL Zone,h,d,y) – PD(WH,h,d,y))
- CCONG(h,d,y) = (PD(DPL Zone,h,d,y) – PD(WH,h,d,y))
- OUTCONG measures congestion due to transmission outages
- CCONG measure congestion due to all causes
- Transmission owner is affliate of load-serving entity (that owns local generation) that has substantial CRR holdings

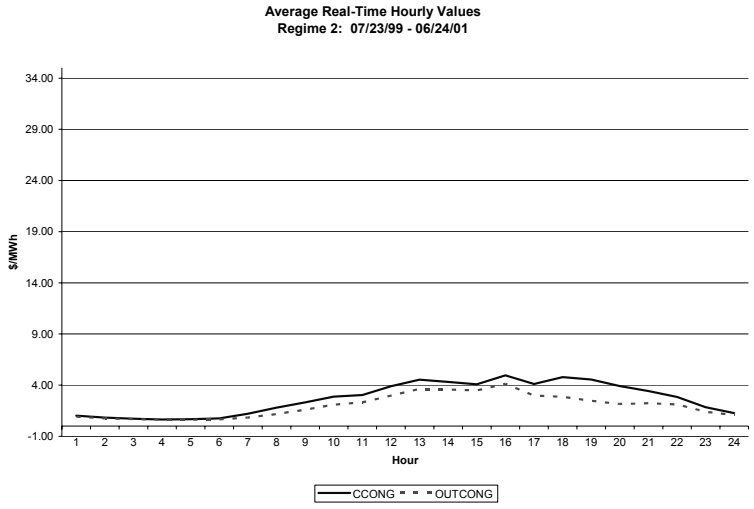
Using CRRs to Profit From Transmission Outages in PJM Market

- Regime 1—Little incentive to use transmission outages to cause congestion because transmission owner had fixed price contract with retailer in DPL Zone
  - No relationship between transmission outages and congestion charges to DPL Zone
- Regime 2—Incentive to use transmission outages to cause congestion because fixed contract no longer in force and affiliate of transmission owner possesses significant quantity of CRRs into region
  - Virtually all congestion charges due to transmission outages

Using CRRs to Profit From Transmission Outages in PJM Market



Using CRRs to Profit From Transmission Outages in PJM Market



Efficient CRR Allocations

- Efficient CRR allocation results in all load-serving entities using CRRs as passive hedges against congestion charges not as a revenue source
  - This imposes restrictions on CRR allocations depending on the local generation and transmission network holdings of load-serving entities
  - If all load-serving entities had no transmission or generation holdings virtually any CRR allocation would be efficient
    - Would not distort behavior of any market participants
  - Equity considerations can be accounted for once restrictions implied by efficiency have been taken into account

Non-Distortionary Local Market Power Mitigation

- Goal is to mitigate local market power in a manner that maximizes the competitiveness of energy and congestion management markets
- Combined proposed local market power mitigation mechanism achieves these goals
  - Out-of-merit or must-run units are treated as price-takers with option to be paid variable cost or market clearing price at that location
  - Efficient FTR allocation to LSEs assumes load obligations are net of local generation holdings within own service area
- Mechanism also reduces incentives for consolidation of generation capacity both among merchant firms and LSEs