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# ***Virtual Bidding and Electricity Market Design***

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# Overview and Purpose

- Addresses PJM's recommendations from October 2015 White Paper on virtuals
- Concludes that PJM's recommendations are in certain cases inconsistent with broader principles of market design
- Discusses the benefits of virtual transactions
- Recommends that PJM expand analysis
- Proposes that PJM eliminate uplift allocation for all virtual transactions

# Benefits of Virtual Transactions

- Better price formation between DA and RT
- Increased liquidity
- Moderate or eliminate ability to exercise market power
- Hedging to reduce price variation for RT settlements
- Impacts commitment and dispatch by incentivizing physical generation and load to participate in the DA

# Focus on Deviations is Misleading

- Day-ahead offers from physical generators and bids from physical loads can deviate significantly from actual real-time outcomes.
- Differences between real-time conditions and what was expected day-ahead caused by uncertain outcomes appear identical to virtual transactions in the ISO settlement accounting.
- Without virtual bids and offers, the resulting day-ahead commitment and dispatch could deviate significantly from the requirements in real-time.
- Deviations do not go hand-in-hand with added uplift costs.

## 1. Deviations without uplift or efficiency effects

- Price equilibrium between DA and RT does not mean that prices are identical between DA and RT.
- Some deviations are expected and inevitable.

## 2. Uplift Without Deviations or Efficiency Effects

- Uplift can arise for many reasons, and may not have any efficiency effects
- For example, when DA dispatch involves unit commitment costs
- Lumpiness of unit commitment costs can give rise to a situation where there is no market clearing price in the day-ahead market that fully supports the solution
- Virtual transactions would smooth the day-ahead commitment and dispatch problem and reduce uplift

### 3. Deviations with Uplift But No Efficiency Effects

- Example: High-priced generator does not clear in the DA market because it is high-priced. But it may be needed for reliability, so it will clear in a later reliability run. Its costs will be covered through uplift.
- Uplift is charged in this scenario. There would be deviations because RT differs from DA. RT dispatch is efficient because the unit needed for reliability has been committed.

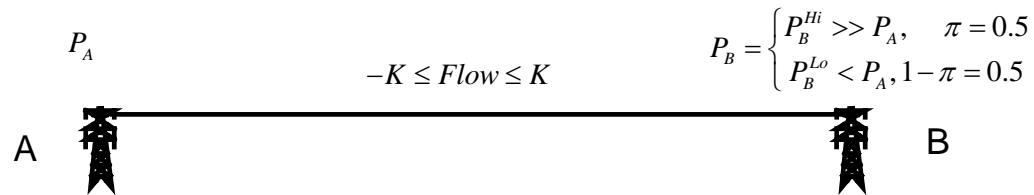
## 4. Equilibrium Analysis

- No single connection between deviations, uplift and efficiency effects
- Perform efficiency analysis of the impact of virtual trading
  - Efficiency of outcome with and without virtual trading?
  - How to quantify effect of different unit commitment results under uncertainty, separate from dispatch?
- California study concluded that the introduction of virtual bidding improved price convergence (Jha & Wolack, 2015)
- ISO-NE study concluded that virtuals reduce price deviations and leads to Day-Ahead dispatch results that are closer to those of Real-Time, and improves ability of RTO to ensure system security (Guler, Gross, Litvinov, & Coutu, 2010)



# Day Ahead Price Equilibrium

## Day-Ahead Price Equilibrium



### Expected Values

$$E(P_A) = P_A$$

$$E(\mu_{ab}) = 0.5(P_B^{Hi} - P_A)$$

$$E(\mu_{ba}) = 0.5(P_A - P_B^{Lo})$$

$$E(P_B) = 0.5(P_B^{Lo} + P_B^{Hi}) > P_A$$

$$E(Flow) = 0.5(K) + 0.5(-K) = 0$$

$\mu$  : Constraint Shadow Price

$\pi$  : Scenario Probability

### Day-Ahead Dispatch

$$P_A^{DA} = P_A$$

$$P_B^{DA} = E(P_B)$$

$$\mu_{ab}^{DA} = E(P_B) - P_A < E(\mu_{ab})$$

$$\mu_{ba}^{DA} = 0 < E(\mu_{ba})$$

$$Flow^{DA} = K$$

# Discussion Points

## Settlements and Cost Allocations

1. Energy Uplift for Residual Costs
2. Virtual Trading and Financial Contracts
3. Consequences of Uplift Allocations
4. Further Restrictions on Virtuals Are Problematic

## Energy Uplift for Residual Costs

- Accomplish cost allocation conforming to the cost causation principle.
- Strive to allocate costs in a way that would have the least adverse impact on the choices made in the market
- Allocating costs based on deviations of individual bidder creates perverse incentives
- Financial contracts are highly sensitive to transaction costs, including residual uplift

# Virtual Trading and Financial Contracts

- Residual costs arise independent of financial contracts.
- Inclusion of financial contracts improves the aggregate efficiency of the system.
- There may be some interaction between financial contracts and commitment decisions, but these interactions are intended to reduce total costs, not add to the total costs.
- Total costs, commitment and dispatch should be the focus of any cost analysis of the impact of financial transactions on the day-ahead market.

# Consequences of Uplift Allocations

- Benefits of financial contracts threatened by any increase in transaction costs or allocation of residual costs.
- Withdrawal from market.
- Return to the external bilateral market where transaction costs are higher but deviations are not used as a basis for residual cost allocations.
- Even small increases in transaction costs can have a material effect on the activity of financial participants.

# Restrictions on Virtual Transactions

## Existing restrictions

- UTCs are limited to a \$50 +/- spread
- UTCs are available at only limited nodes representing about 3% of the PJM system
- Companies are subject to a “soft cap” of 3,000 UTC transactions in an operating day

## Proposed restrictions

- Proposing to remove approximately 70% of INC/DEC nodes
- Proposing to remove approximately 25% of UTC nodes
- Proposing to only allow UTCs to source at a generator and sink at a load zone, which will effectively eliminate all counterflow UTCs

# Restrictions are unsupported

“The PJM recommendations restricting the use of virtual transactions do not follow necessarily even from a narrower evaluation perspective. The principal problem PJM identifies with virtual transactions is a computational burden that would be only indirectly affected by uplift allocations, and **could be addressed through other means** with fewer negative consequences for the broader market design ... .”

- Other, less restrictive options are available to address PJM’s concerns

# Primary Findings

- **Restricting explicit virtual bidding**, as PJM proposes, **creates market power** for those who can make implicit virtual bids.
- The principal problem PJM identifies with virtual transactions is a **computational burden** that would be only indirectly affected by uplift allocations, and could be **addressed through other means** with fewer negative consequences for the broader market design, such as by continuation of bidding budgets that allowed flexibility in the choice of virtual transactions.
- PJM's own analysis provides many examples of the contributions and effects of virtual bidding, but **does not connect the examples to the broader framework** of electricity market design principles



# Primary Findings, con't

“The PJM report provides many illustrative examples and useful discussions of the benefits of virtual bidding. However, the discussion **arises in a context where virtual bidding is under attack**. By its very nature, the efficiency benefit of virtual bidding arises from dealing with uncertainty. A full treatment of uncertainty has not been done, but even a partial analysis indicates that recommendations for reforms of virtual bidding and associated cost allocations would go in an entirely different direction from that appearing in the PJM report.”

- Need more analysis from neutral standpoint
- PJM's analysis does not support its proposed remedies

# Recommendations

- Analyze impact of virtual trading on unit commitment decisions rather than assumed differences between DA and RT dispatch choices or transmission flows.
- Eliminate uplift allocation for all virtual transactions
  - Apply residual costs to load, the beneficiary of the market action resulting in uplift
- Increase, rather than decrease, the points at which virtual transactions may be placed.

# Questions?

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