Convergence Bidding Tutorial & Panel Discussion

CAISO

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PJM Market Monitor

Convergence Basics

- Day-Ahead Market basics
- Day-Ahead and Real-Time Market interactions
- Increment offers (incs) and decrement bids (decs)
- Roles of incs and decs
- Examples
- Review of PJM results
- Issues

Two Energy Markets

- Day-Ahead Energy Market
  - Develop day-ahead schedule using least-cost security constrained unit commitment and dispatch
  - Calculate hourly LMPs for next operating day using generation offers, demand bids and bilateral transaction schedules
  - Objective is to develop set of financial schedules that are physically feasible
- Real-Time Energy Market
  - Calculate hourly LMPs based on actual system operating conditions

Day-Ahead Energy Market

- A Day-ahead hourly forward market for energy
- Provides the option to obtain increased certainty:
  - Purchase of MW at Day-ahead prices
  - Sale of MW at Day-ahead prices
  - Day-ahead congestion
- Price-sensitive demand
- Increment offers
- Decrement bids
- PJM Capacity Resources must submit offers
- Participation by load is optional

Reserve Adequacy Assessment

- Reserve adequacy assessment is designed to ensure adequate generating resources to meet forecast actual load in real time
- Additional generating resources scheduled after day-ahead market clears
- Based on PJM load forecast, physical generation assets, actual transaction schedules (net tie schedules) and full PJM operating reserve requirements
- Virtual bids and offers not included
- To preserve economic incentives, any additional unit commitment is based on minimizing cost to provide additional reserves (minimize startup and no-load costs)

Two Energy Market Settlements

- Day-Ahead Market Settlement
  - Based on scheduled hourly MW quantities and day-ahead LMPs
- Balancing Market Settlement
  - Based on hourly MW quantity deviations between real-time and day-ahead
  - MW quantity deviations settled at real-time LMPs

Day-Ahead Market Implications

- Day-ahead schedules are financially binding
- Demand scheduled day-ahead
  - Pays day-ahead LMP for day-ahead MW scheduled
  - Pays real-time LMP for actual MW above scheduled
  - Paid real-time LMP for actual MW below scheduled
- Generation scheduled day-ahead
  - Paid day-ahead LMP for day-ahead MW scheduled
  - Paid real-time LMP for actual MW above scheduled
  - Pays real-time LMP for actual MW below scheduled

- Available to all Market Participants
- Do not require physical generation or load
- Consist of:
  - MW offer or bid
  - Price of offer or bid (may be negative)
- Submitted at any hub, transmission zone, aggregate, or single bus for which LMP is calculated
- Supported in Day-ahead market only
  - Deviation in Real-time market
- Operating Reserve Charge Implications

Increment Offers

- Looks like a spot sale or dispatchable resource
- “If the price goes above X, then I will sell to the day-ahead PJM spot market”

Decrement Bids

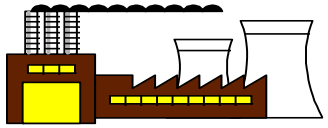
- Looks like spot purchase or price sensitive demand
- “If price goes below X then I will buy from the day-ahead PJM spot market”

Why Use an Inc or Dec?

- Cover one side of a bilateral transaction
- Cover eSchedules deal
  - allows opposite party access to real-time LMP while you participate in day-ahead
- Hedge a Day-ahead generation offer
  - Use a decrement bid
- Arbitrage Day-ahead to Real-time pricing
  - Use an increment offer or decrement bid
- Hedge Day-ahead Demand bid

Example #1 - Increment Offer

Day-ahead



Participant offers 100 MW at $30

Assume Day ahead LMP= $25

Increment Offer does not clear

Day-ahead position is 0

Real-time

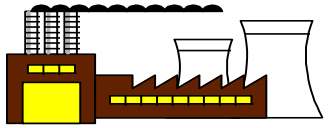
Increment Offer did not clear

Balancing Settlement = 0 (no deviation)

Net position = 0

Example #2 - Increment Offer

Day-ahead



Participant offers 100 MW at $30

Assume Day ahead LMP= $35

Day ahead Settlement = 100 MW * $35 = $3500 credit

Real-time

Assume Real-time LMP = $20

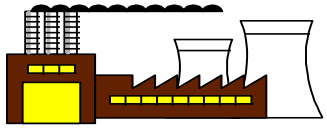
Deviation from DA schedule = -100 MW

Balancing Settlement = -100 MW * $20 = $2000 charge

Net position = $3500-$2000 = $1500 credit

Example #3 - Increment Offer

Day-ahead

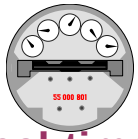


Participant offers 100 MW at $30

Assume Day ahead LMP= $35

Day ahead Settlement = 100 MW * $35 = $3500 credit

Real-time



Assume Real-time LMP = $40

Deviation from DA schedule = -100 MW

Balancing Settlement = -100 MW * $40 = $4000 charge

Net position = $3500-$4000 = $500 charge

Example #1 - Decrement Bid

Day-ahead

Participant bids 100 MW at $20

Assume Day ahead LMP= $25

Decrement bid does not clear

Day-ahead position is 0

Real-time

Decrement bid did not clear

Balancing Settlement = 0 (no deviation)

Net position = 0

Example #2 - Decrement Bid

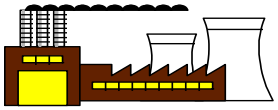
Day-ahead

Participant bids 100 MW at $20

Assume Day ahead LMP= $15

Day ahead Settlement = 100 MW * $15 = $1500 charge

Real-time



Assume Real-time LMP = $25

Deviation from DA schedule = 100 MW

Balancing Settlement = 100 MW * $25 = $2500 credit

Net position = -$1500+$2500 = $1000 credit

Example #3 - Decrement Bid

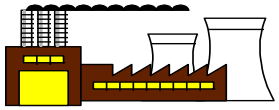
Day-ahead

Participant bids 100 MW at $20

Assume Day ahead LMP= $15

Day ahead Settlement = 100 MW * $15 = $1500 charge

Real-time



Assume Real-time LMP = $10

Deviation from DA schedule = 100 MW

Balancing Settlement = 100 MW * $10 = $1000 credit

Net position = -$1500+$1000 = $500 charge

Example - Decrement Bid

Self-scheduled generator (200 MW) wants to see Real-time pricing

Day-ahead

Generator self-schedules unit at 200MW

Decrement bid at same bus for 200 MW at $100

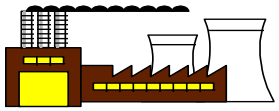
Assume Day ahead LMP= $30

Day ahead Settlement (Gen) = 200 MW * $30 = $6000 credit

Day ahead Settlement (Dec) = 200 MW * $30 = $6000 charge

Net Day ahead Position = 0

Real-time



Assume Generator produces 200 MW

Assume Real-time LMP = $35

Deviation from DA schedule (Gen) = 0 MW

Deviation from DA schedule (Dec) = 200 MW

Balancing Settlement (Gen) = 0 MW * $35 = 0

Balancing Settlement (Dec) = 200 MW * $35 = $7000 credit

Balancing Position = $7000 credit

Net position = 0 + $7000
= $7000 credit

Internal Bilateral – Seller wants RT Pricing, Buyer wants DA pricing

Day-ahead Buyer

100 MW Transaction entered as DA in eSchedules

Assume Day ahead LMP= $40

Day ahead Settlement (Purchase) = 100 MW * $40 = $4000 credit

Net Day ahead Position = $4000

Real-time Buyer

100 MW transaction carries over to RT

Assume Real-time LMP = $50

Deviation from DA schedule (Sale) = 0 MW

Balancing Settlement (Sale) = 0 MW * $50 = $0

Balancing Position = $0

Net position = $4000 + $0
= $4000 credit

Internal Bilateral – Seller wants RT Pricing, Buyer wants DA pricing

Day-ahead Seller

100 MW Transaction entered as DA in eSchedules

Seller enters Increment offer at same location for 100 MW at low price

Assume Day ahead LMP= $40

Day ahead Settlement (Inc) = 100 MW * $40 = $4000 credit

Day ahead Settlement (Sale) = 100 MW * $40 = $4000 charge

Net Day ahead Position = 0

Real-time Seller

100 MW transaction carries over to RT

Assume Real-time LMP = $50

Deviation from DA schedule (INC) = -100 MW

Deviation from DA schedule (Sale) = 0 MW

Balancing Settlement (INC) = -100 MW * $50 = $5000 charge

Balancing Settlement (Sale) = 0 MW * $50 = $0

Balancing Position = $5000 charge

Net position = 0 + $5000 = $5000 charge

Example - Decrement Bid with Generator

Generator in danger of a forced reduction in real-time (i.e. mech. Failure)

Day-ahead Generator

200 MW Scheduled Generation

Dec bid 100 MW @ $20

Assume Day ahead LMP= $15

Day ahead Settlement (Gen) = 200 MW * $15 = $3000 credit

Day ahead Settlement (DEC) = 100 MW * $15 = $1500 charge

Net Day ahead Position = 1500 credit

Real-time Generator

Generator produces 100 MW

Assume Real-time LMP = $20

Deviation from DA schedule (GEN) = -100 MW

Deviation from DA schedule (DEC) = 100 MW

Balancing Settlement (GEN) = -100 MW * $20 = $2000 charge

Balancing Settlement (DEC) = 100 MW * $20 = $2000 credit

Balancing Position = $0

Net position = $1500 + $0 = $1500 credit

Without DEC

Net credit = $1000

Example - Hedge Day-ahead Demand Bid

Demand bid hedged with a Decrement Bid

Day-ahead Demand

100 MW Scheduled Demand

Dec bid 20 MW @ $20

Assume Day ahead LMP= $15

Day ahead Settlement (Demand) = 100 MW * $15 = $1500 charge

Day ahead Settlement (DEC) = 20 MW * $15 = $300 charge

Net Day ahead Position = 1800 charge

Real-time Demand

Real-time Demand = 110 MW

Assume Real-time LMP = $20

Deviation from DA schedule (DEMAND) = 10 MW

Deviation from DA schedule (DEC) = 20 MW

Balancing Settlement (DEMAND) = 10 MW * $20 = $200 charge

Balancing Settlement (DEC) = 20 MW * $20 = $400 credit

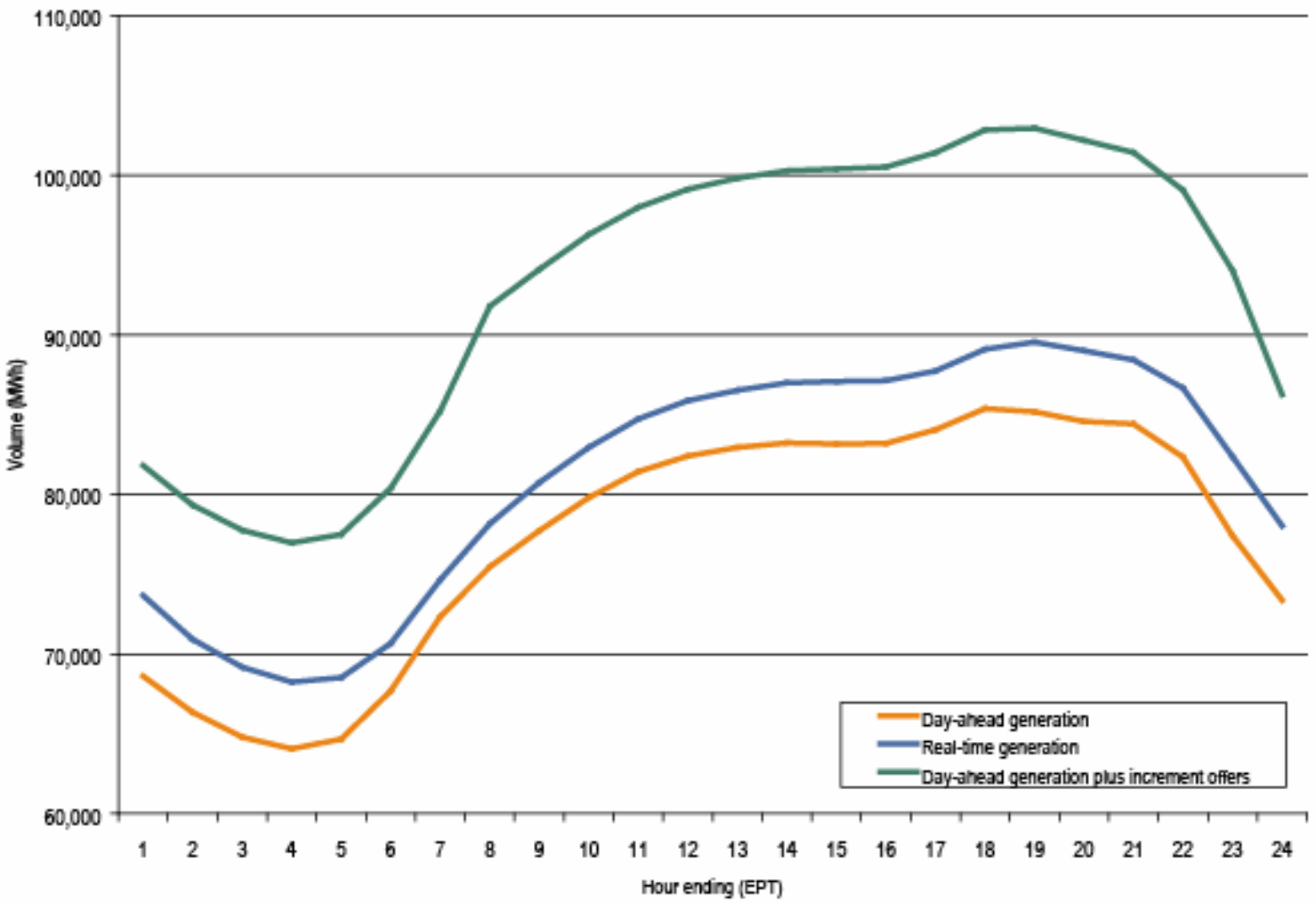
Balancing Position = $200 credit

Net position = $1800 - $200 = $1600 charge

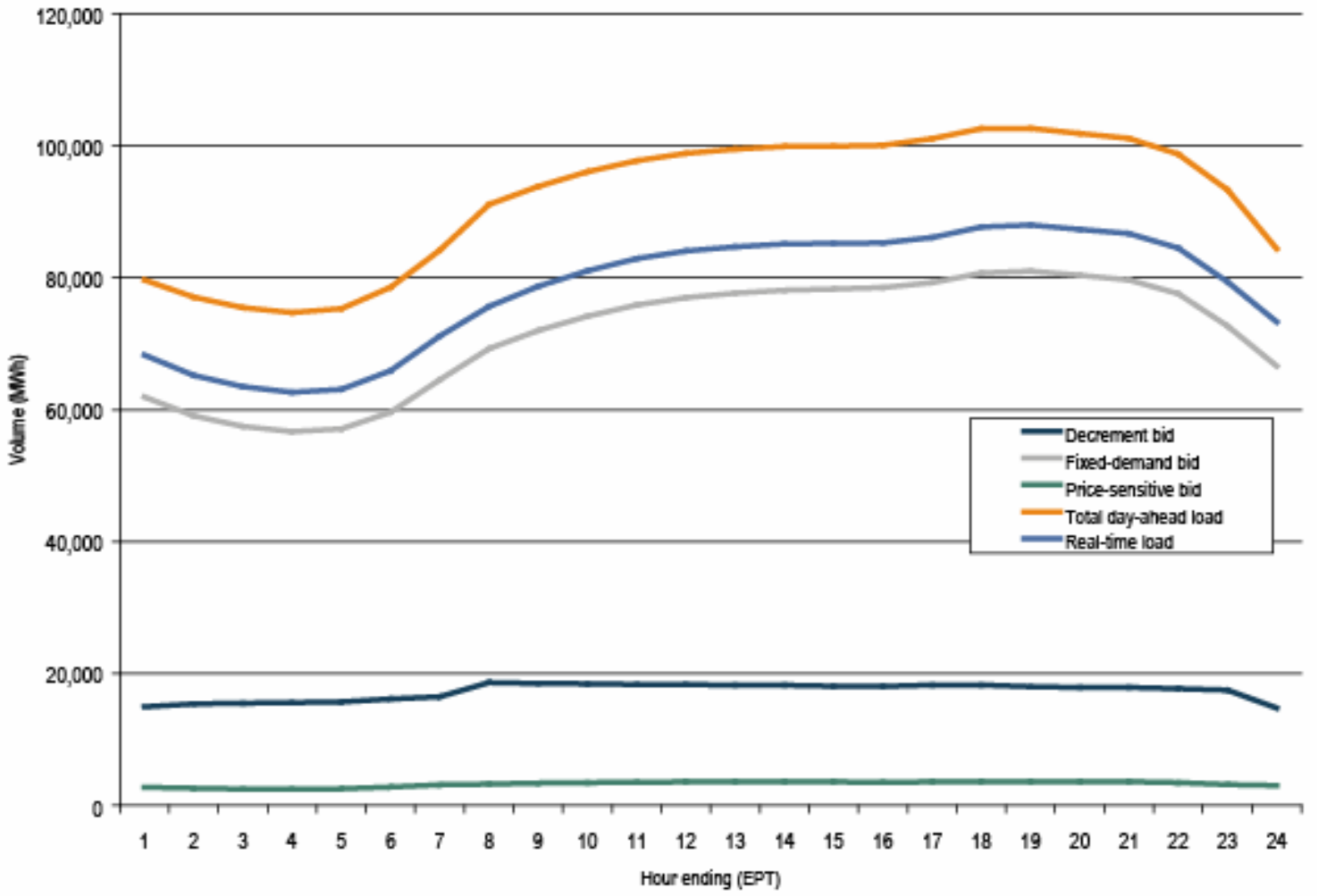
Without DEC

Net charge= $1700

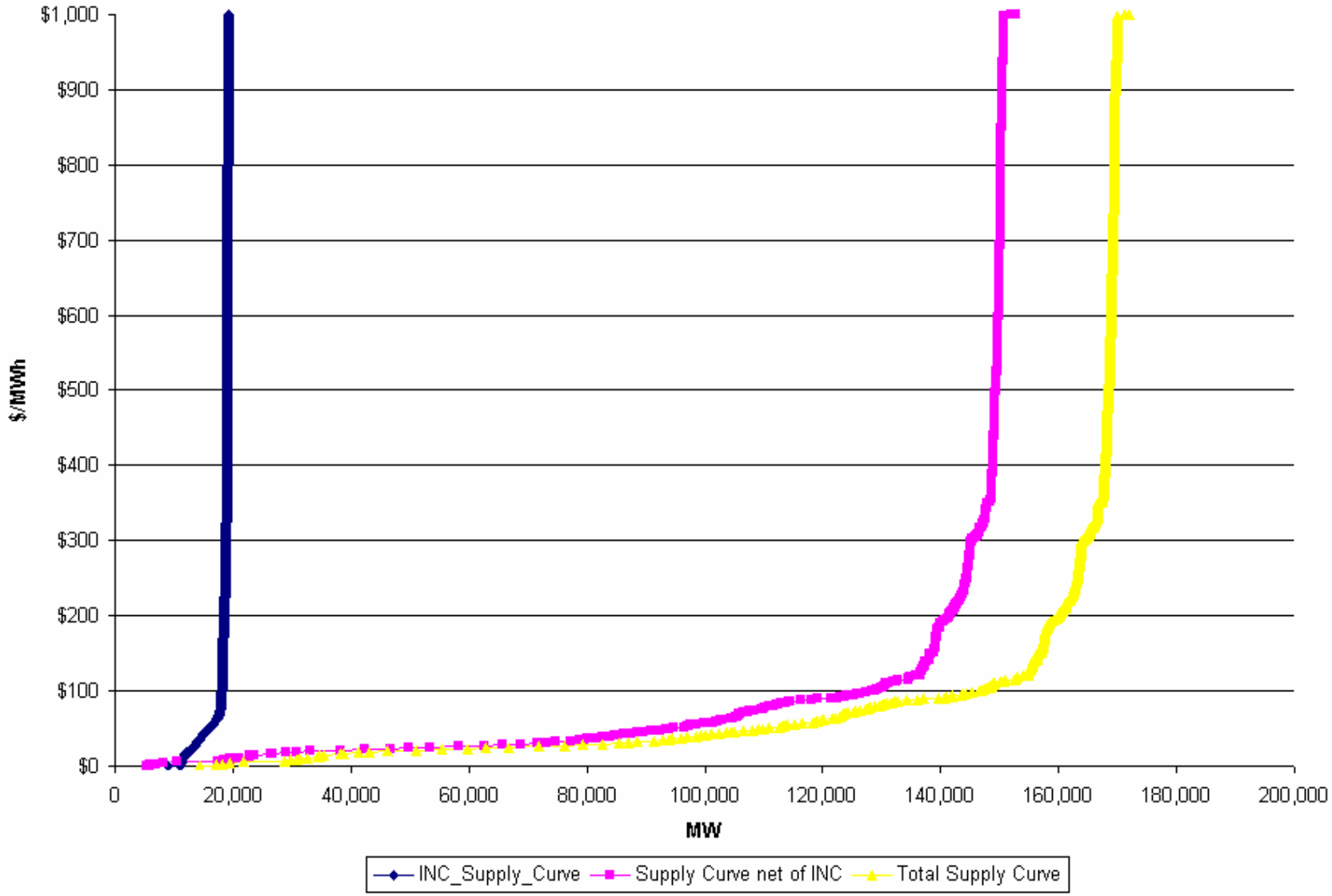
Day-ahead and Real-time Generation: 2005



Day-ahead and Real-time Loads: 2005

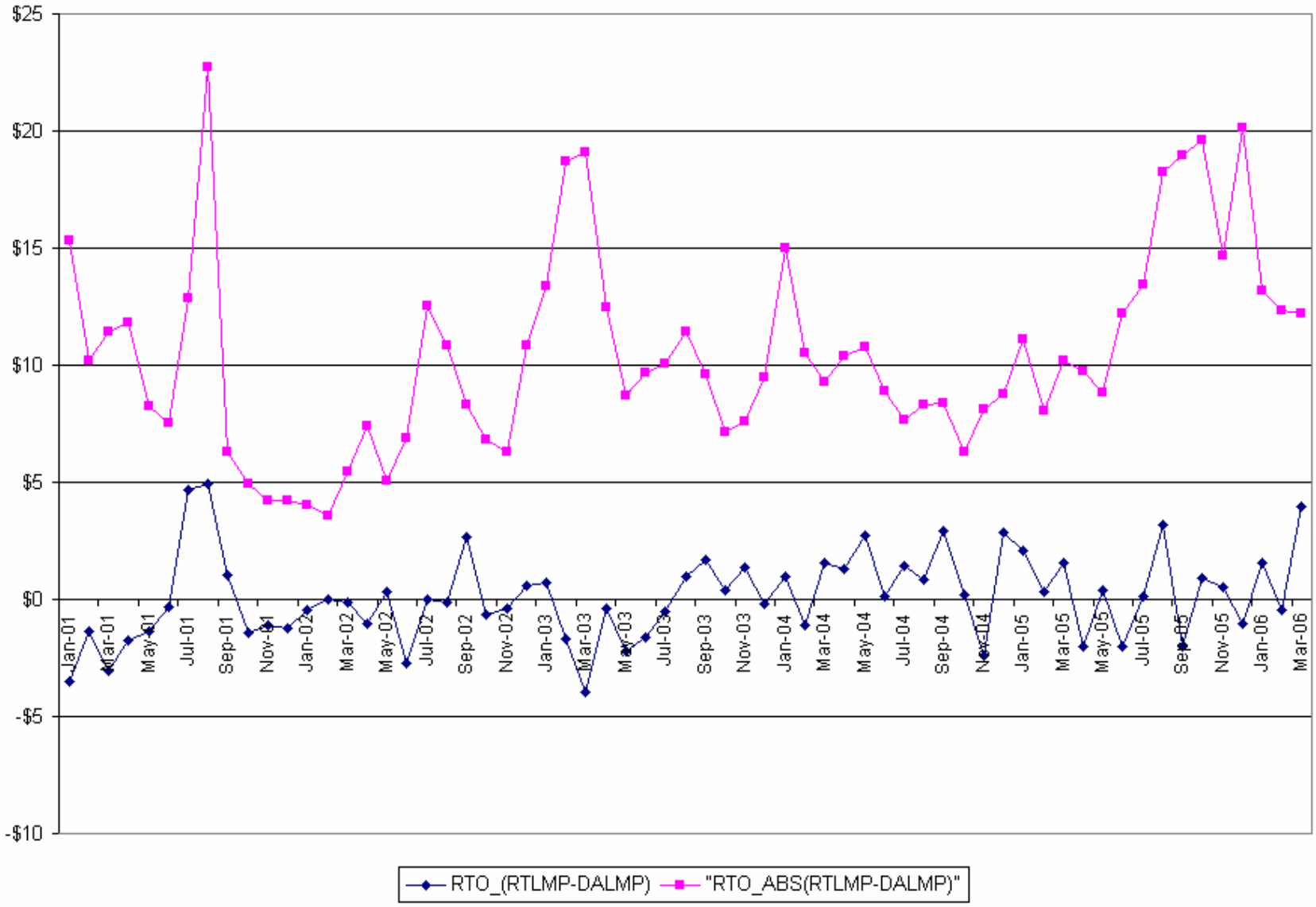


PJM Day-Ahead Aggregate Supply Curves – Example Day

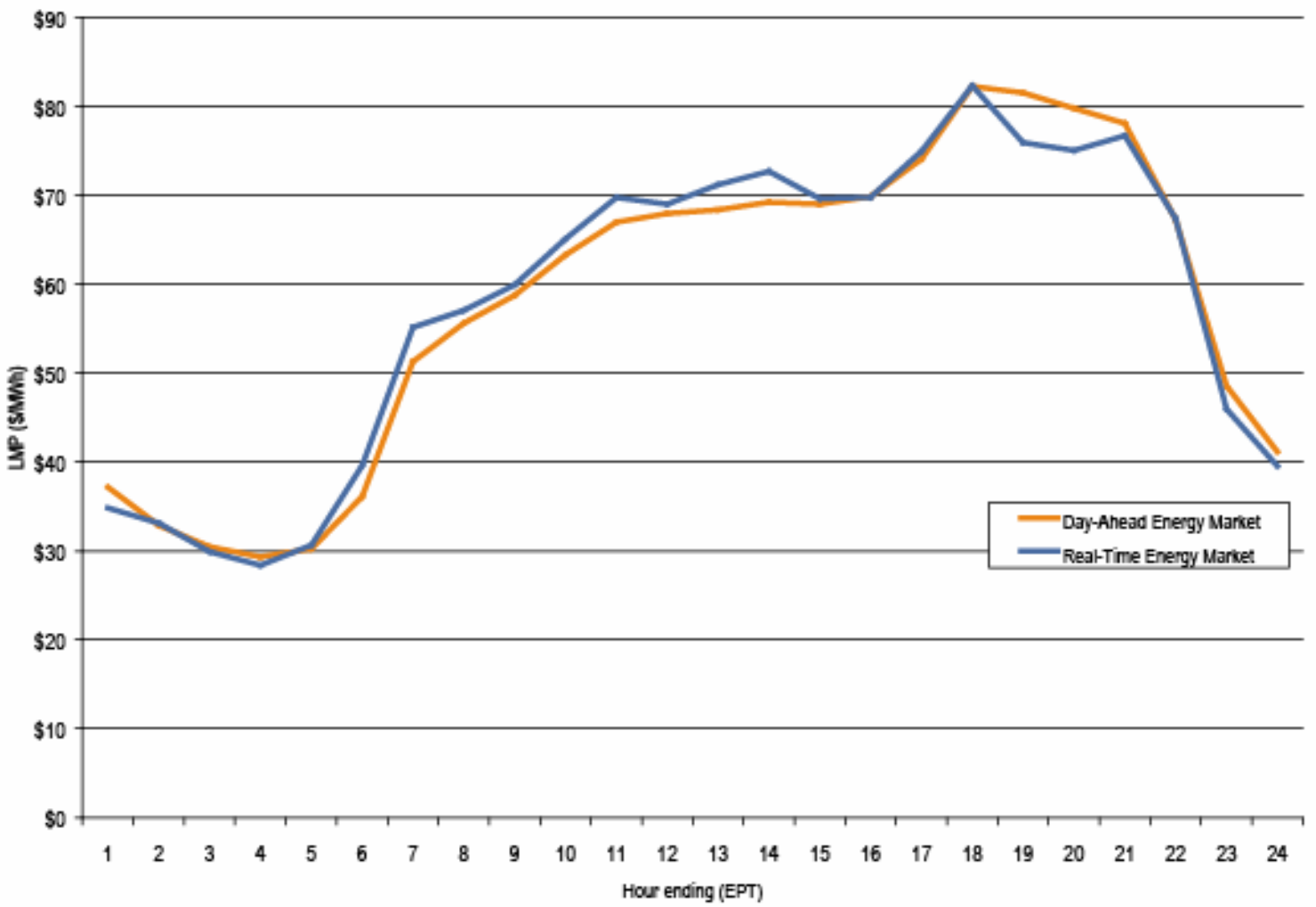


RTO Convergence – Yearly Mean

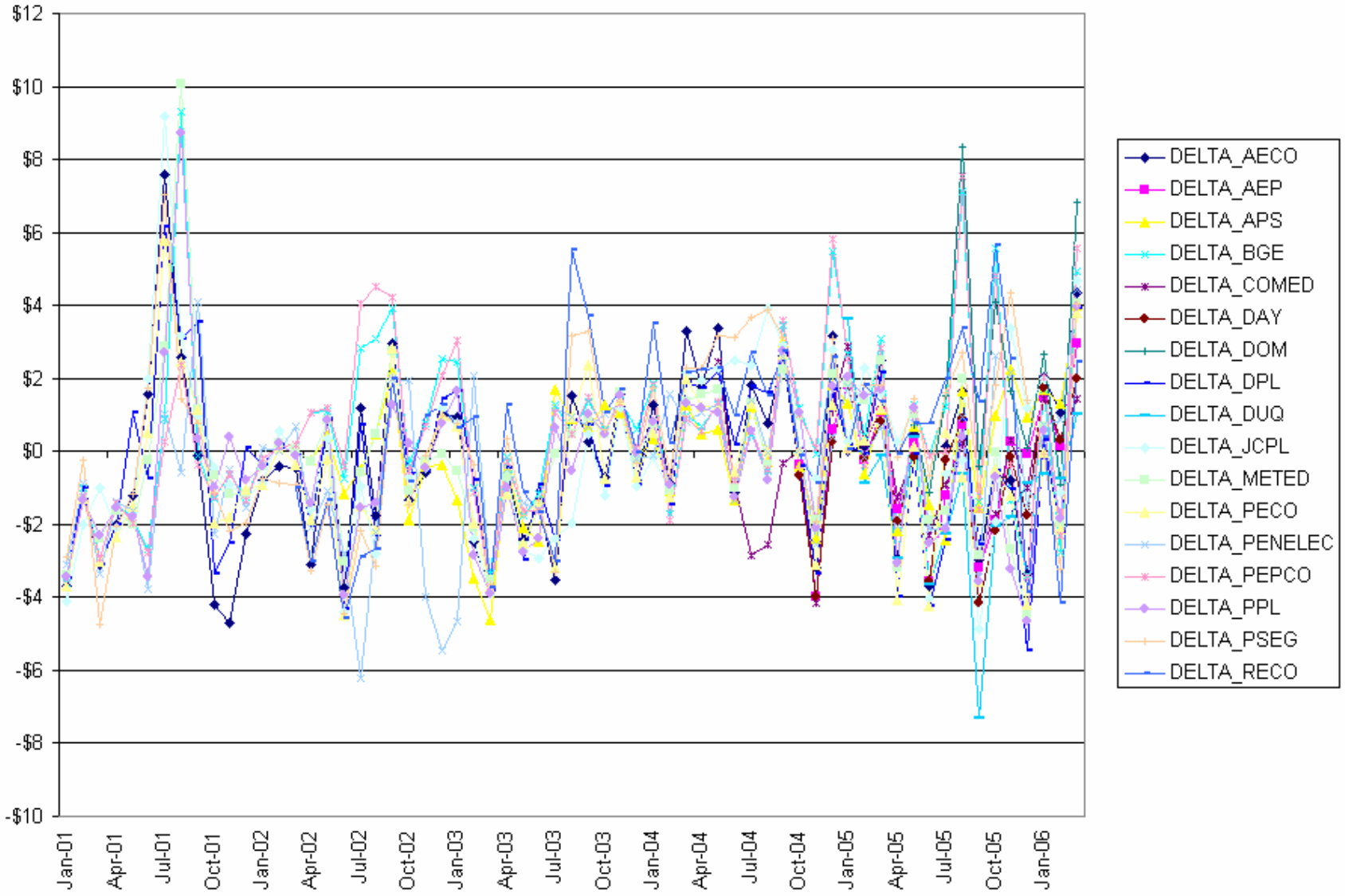
RTO Convergence – Monthly Mean and Absolute Value



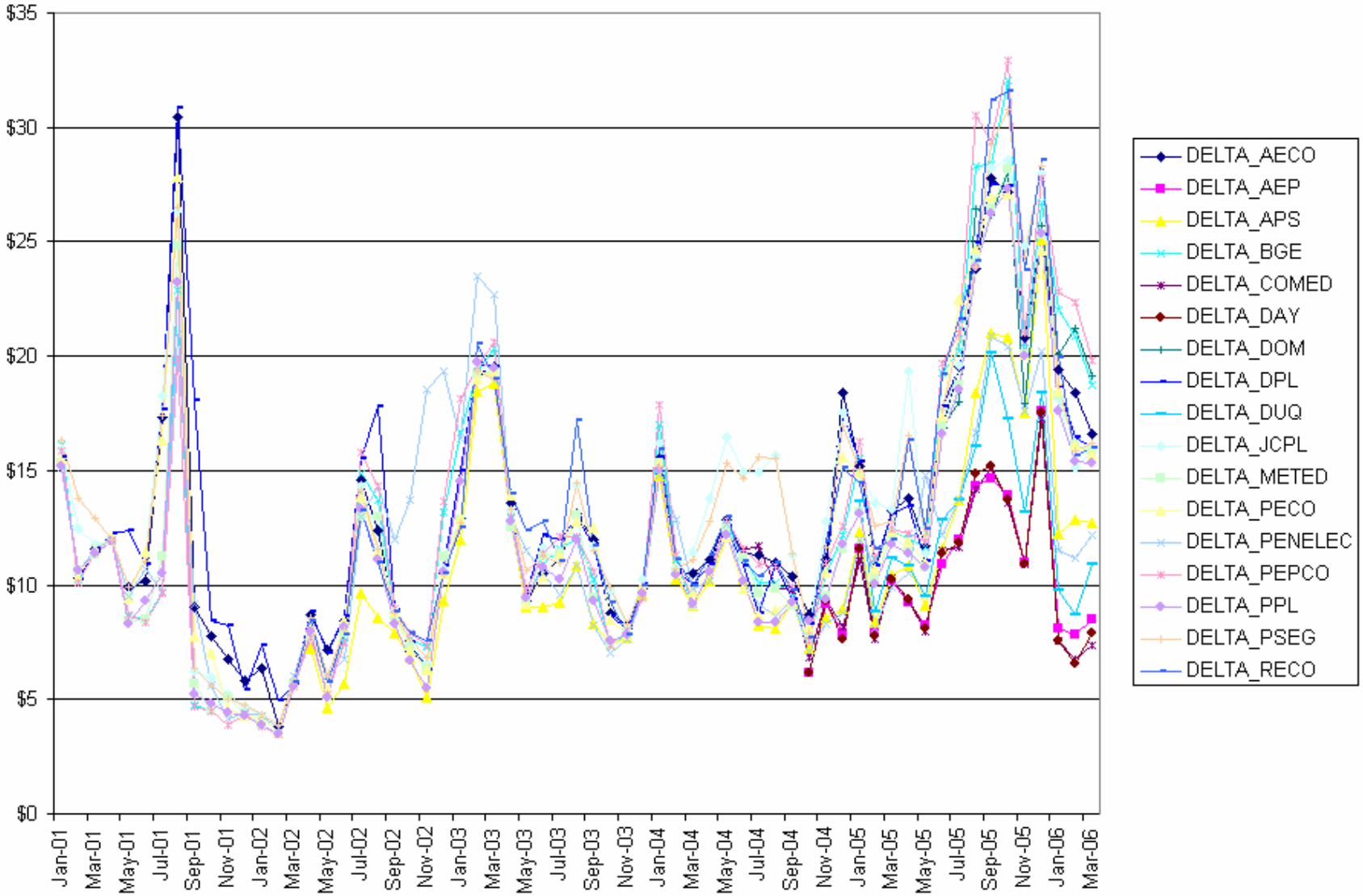
PJM Hourly System Average LMP: 2005



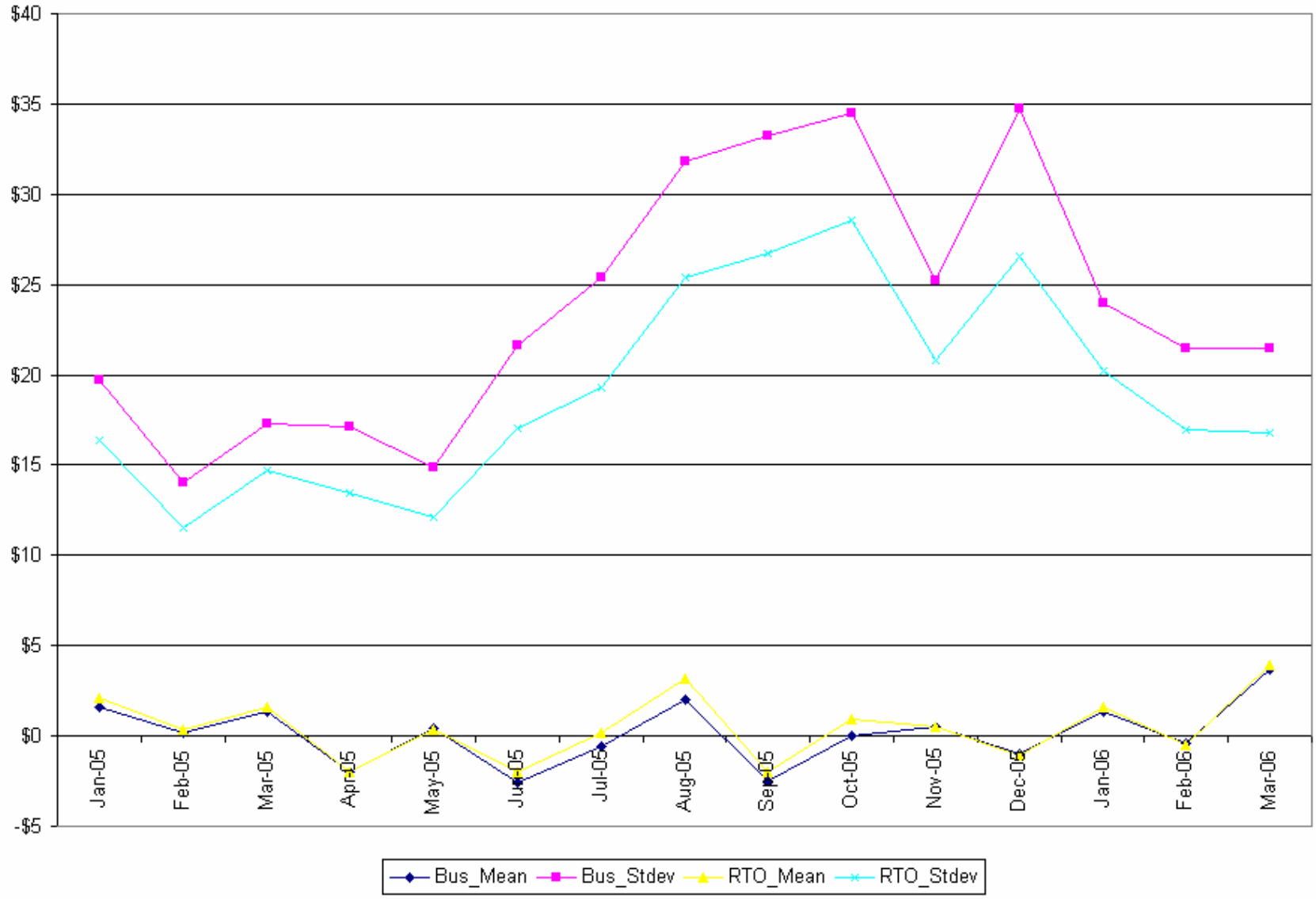
Zonal Convergence – Mean



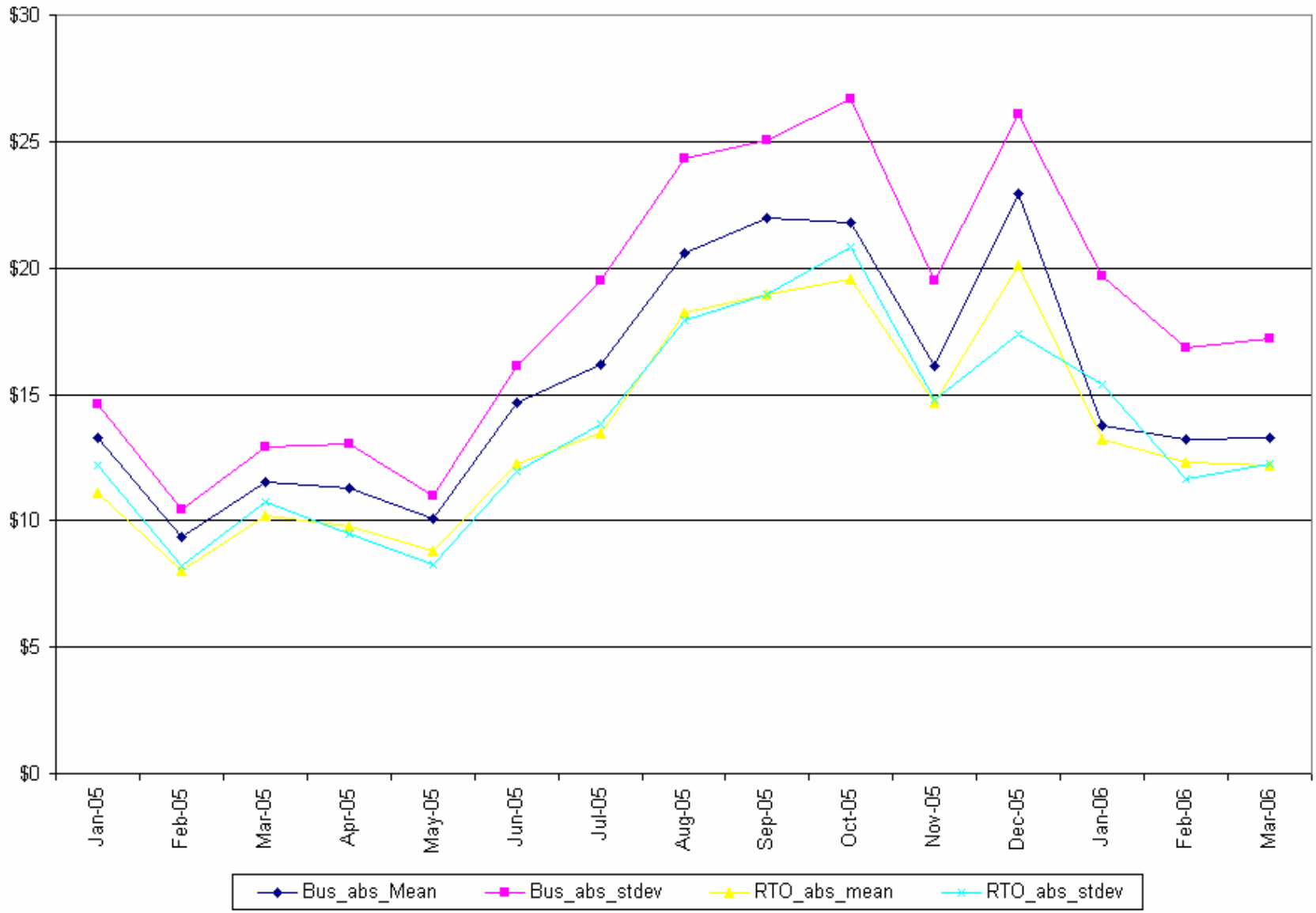
Zonal Convergence – Absolute Value



Bus convergence: Mean and Standard Deviation



Bus convergence – Absolute Value



Convergence Issues

- Market power issues
  - Ability to create congestion in day-ahead market
  - Ability to make FTRs more valuable
- Rule to address this issue is in PJM Operating Agreement
- Limits on level of increment offers and decrement bids
  - PJM does not currently have limits
  - Should be considered
- Credit requirements
  - PJM has credit requirements for participation