

DC ENERGY

QUANTITATIVE TRADING

Effects of 4/25/06 FERC RSG Order on Convergence of MISO markets

October 6, 2006

DC ENERGY
QUANTITATIVE TRADING

WASHINGTON, D.C.
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Agenda



- **Executive Summary**
- **Background**
- **Hypothesis 1: Impact on Virtual Supply-Demand Ratio**
- **Hypothesis 2: Impact on DA-RT Power Price Premium**
- **Hypothesis 3: Impact on absolute DA-RT Power Price Divergence**
- **Backup**
 - Theoretical Post-RSG-Order Equilibrium
 - Convergence in Other ISO Markets

Executive Summary **– Effects of 4/25/06 FERC RSG Order –**

- **FERC order on 4/25/06 subjects virtual supply bids (INCs) to a new and significant incremental transaction charge (RSG). This has materially impacted the DA market by drastically reducing the number of cleared INC (~50% decrease) and DEC transactions (~40% decrease).**
- **Has this new charge hurt the efficiency of the market? We examine this question by testing three hypothesis.**
 - Hypothesis 1: The ratio of cleared INC to cleared DEC transactions has significantly declined, resulting in excessive plant dispatch in the day ahead market
 - Hypothesis 2: The average premium (bias) of the DA market to the RT market has significantly increased, thus raising costs for consumers of power
 - Hypothesis 3: The hourly absolute DA to RT market divergence has increased significantly, thus impairing the efficiency of plant dispatch
- **Analysis of Market Data from 4/27/06 to 8/14/06 shows strong support for all three hypotheses**
 - INC/DEC ratio has clearly decreased since FERC order (99.9% confidence level)
 - DA premium over RT prices has clearly increased (99.9% confidence level for Cinergy Hub; 89-99% confidence for tests at other 3 hubs); impact is greater than \$2/mwh
 - Hourly absolute DA to RT divergence has increased (92% confidence level) based on a comprehensive (all nodes, all hours) measure of divergence
- **Bottom-line impact: Among other negative effects, a \$2 increase in DA premium implies \$400M in additional costs since the imposition of the FERC RSG order...(annualized impact > \$1B)**

Hypothesis testing confirms that the MISO market has been harmed

Data Analysis: MISO DA-RT Market Convergence

Hypothesis Significance (using raw data)

Hypothesis Significance (adjusting for temporal correlation)

Hypothesis 1

The ratio of cleared INC to cleared DEC transactions has declined

- YES
 - >99% Confidence Interval for whole market

- YES
 - >99% Confidence Interval for whole market

Hypothesis 2

The average premium (bias) of the DA market to the RT market has increased

- YES
 - >99% Confidence Interval at Cinergy Hub

- YES
 - >99% Confidence Interval at Cinergy Hub

Hypothesis 3

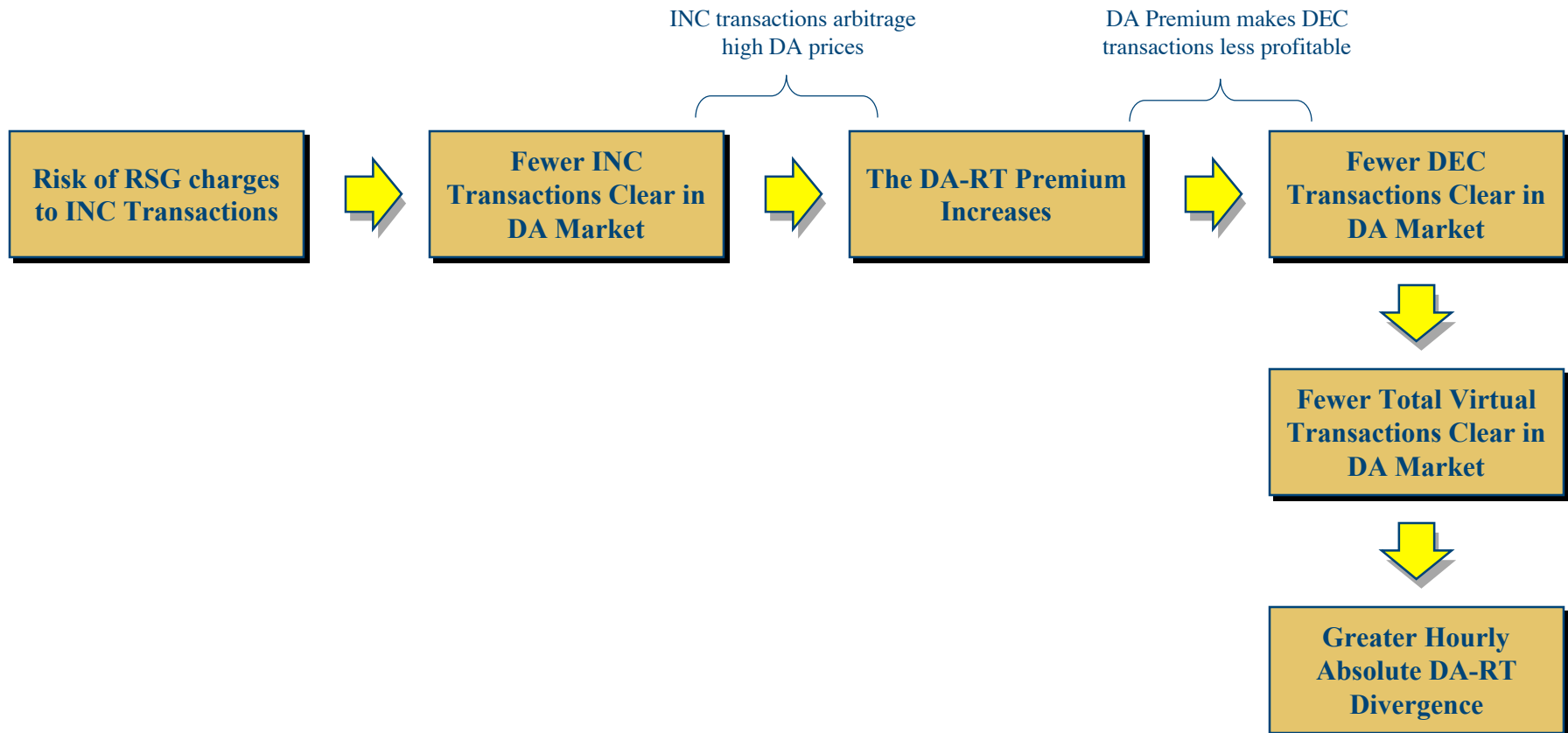
The hourly absolute DA to RT market divergence has increased

- YES
 - >99% Confidence Interval for all nodes

- LIKELY YES
 - ~92% Confidence Interval for all nodes

Why RSG charges to INC transactions can cause an increase in bias and divergence

Logic Tree: RSG Impact on Convergence



Not only is a DA premium bad for the market and consumers, so too is poor DA-RT convergence

Why Convergence is Good

- **Reduces risk premium, i.e., the market price to insure against volatility**
 - Generally means lower prices for consumers
- **More efficient dispatch**
 - Generally means lower energy prices for consumers
- **Incent generation to bid competitively into the DA market**
 - No need to discount chances of receiving a fair price
 - Generally means lower energy prices for consumers



Annual impact to consumers is likely to be greater than the \$1B driven directly by the DA premium increase (these effects are more difficult to measure, but real nonetheless)

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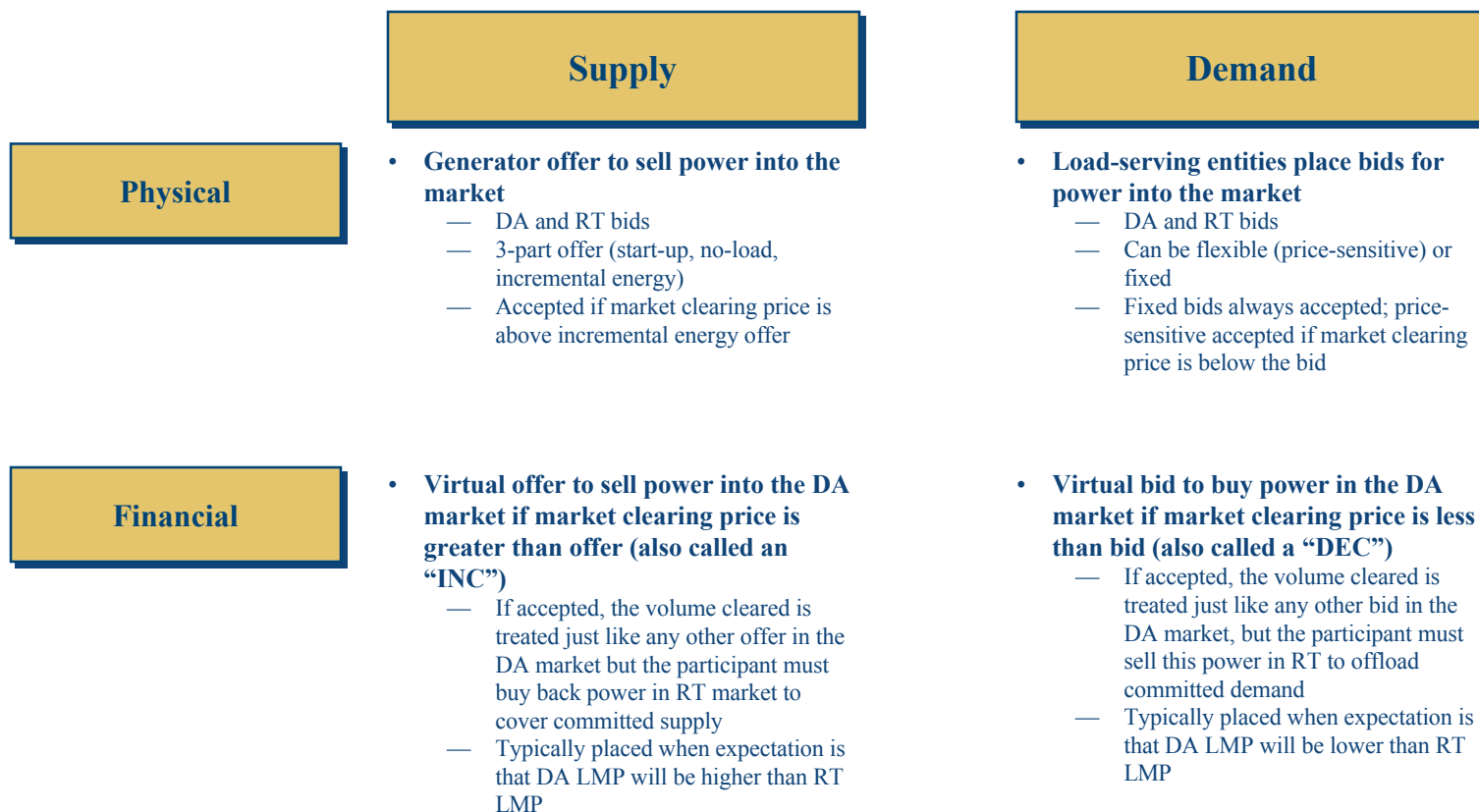
Virtual energy transactions are an integral part of a two-settlement wholesale electricity markets

Virtual Energy Transactions – Introduction –

- **Most LMP markets have a two-settlement system that combines a short term forward (day-ahead) market with a spot (real-time or balancing) market**
 - All electricity markets must have a real-time (RT) market to ensure that instantaneous supply and demand are matched or balanced
 - The day-ahead (DA) market serves as a financial hedge against spot price volatility enabling participants to gain price certainty; it provides a market-based forecast of the real-time market; and it enables ISO to secure majority of generation ahead of time (reliability benefit)
 - PJM started its LMP market with a real-time settlement in 1998, the day-ahead market was introduced in June 2000
 - NYISO started its LMP market in 1999, followed by NE in March 2003, and MISO in April 2005
- **Given that they both describe the same commodity, the prices in the day-ahead and real-time markets ought to converge; financial, or virtual, energy transactions were developed to encourage this convergence**
 - Financial energy transactions consist of increment (INC) offers to sell power in the day-ahead market and decrement (DEC) bids to buy power in the day-ahead market
 - These transactions are purely financial, they automatically close out in the Real-Time market and there is no physical obligation to take or provide power

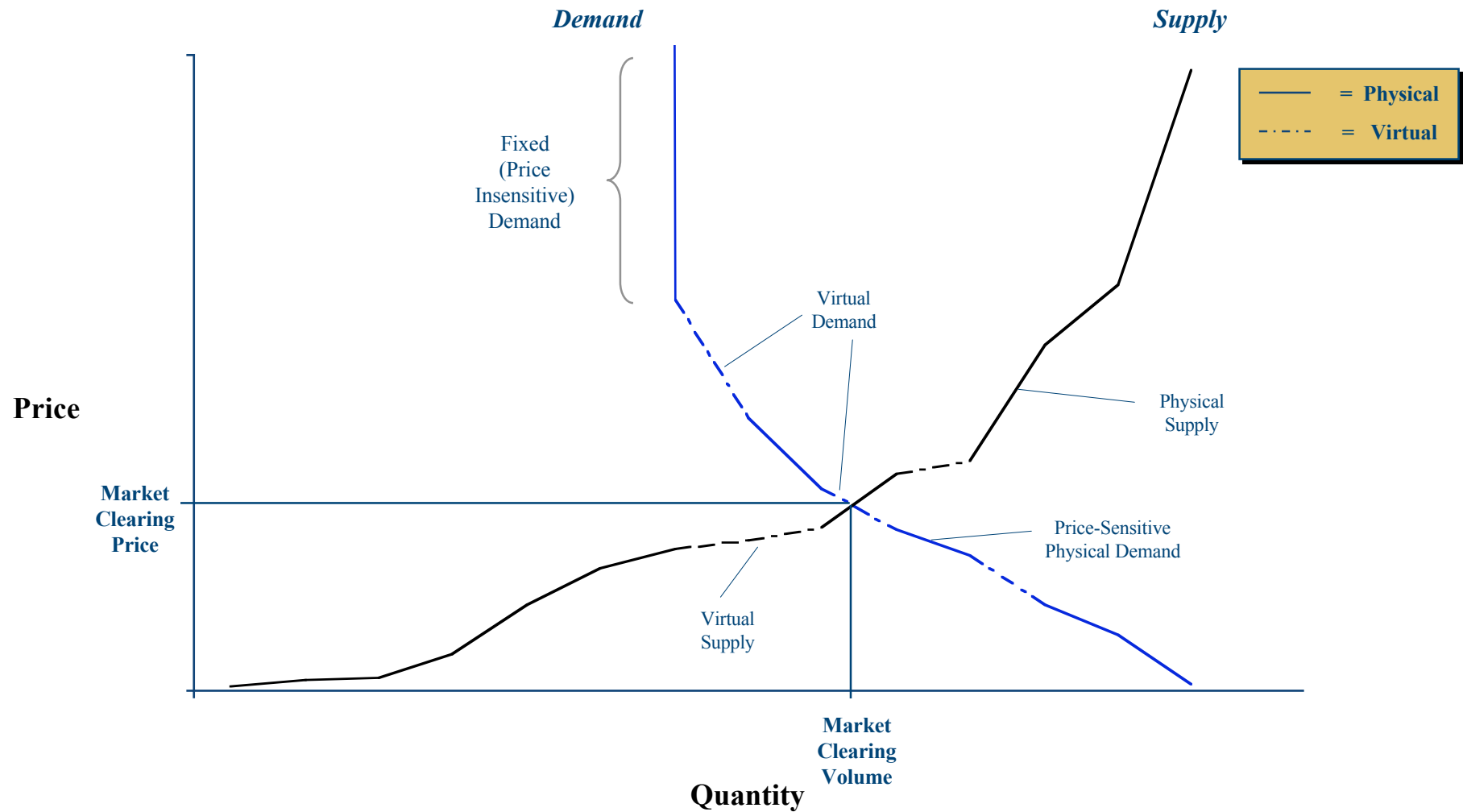
There are essentially four components to the MISO energy market: physical and financial supply and demand

Energy Market Components



In the DA energy market, both physical and financial bids are part of the market solution

DA Energy Market Clearing



Virtual transactions provide numerous benefits to the energy markets

Benefits of Virtual Transactions

- **DA/RT market convergence**
 - Because financial participants seek to arbitrage the difference between the DA and RT markets, the effect is to bring them closer together
- **Liquidity**
 - Ensures that market clears at a fair price even in absence of physical participants
- **Granularity**
 - Physical bids are governed by physical parameters, so there may be price gaps on the stack – but virtuals can be priced anywhere (e.g., if 50/50 chance that \$60 plant needed in addition to \$40 plant, then the appropriate price is \$50 -- which virtuals can provide)
- **Reduces the ability of large participants to exercise market power**
 - Virtual participation means increased overall participation (and hence competition) in the market
- **Risk mitigation**
 - Enables participants to hedge other physical and financial positions (physical example: generators can submit DEC's to hedge some of the risk if their unit trips offline unexpectedly)

Definition of Revenue Sufficiency Guarantee (RSG)

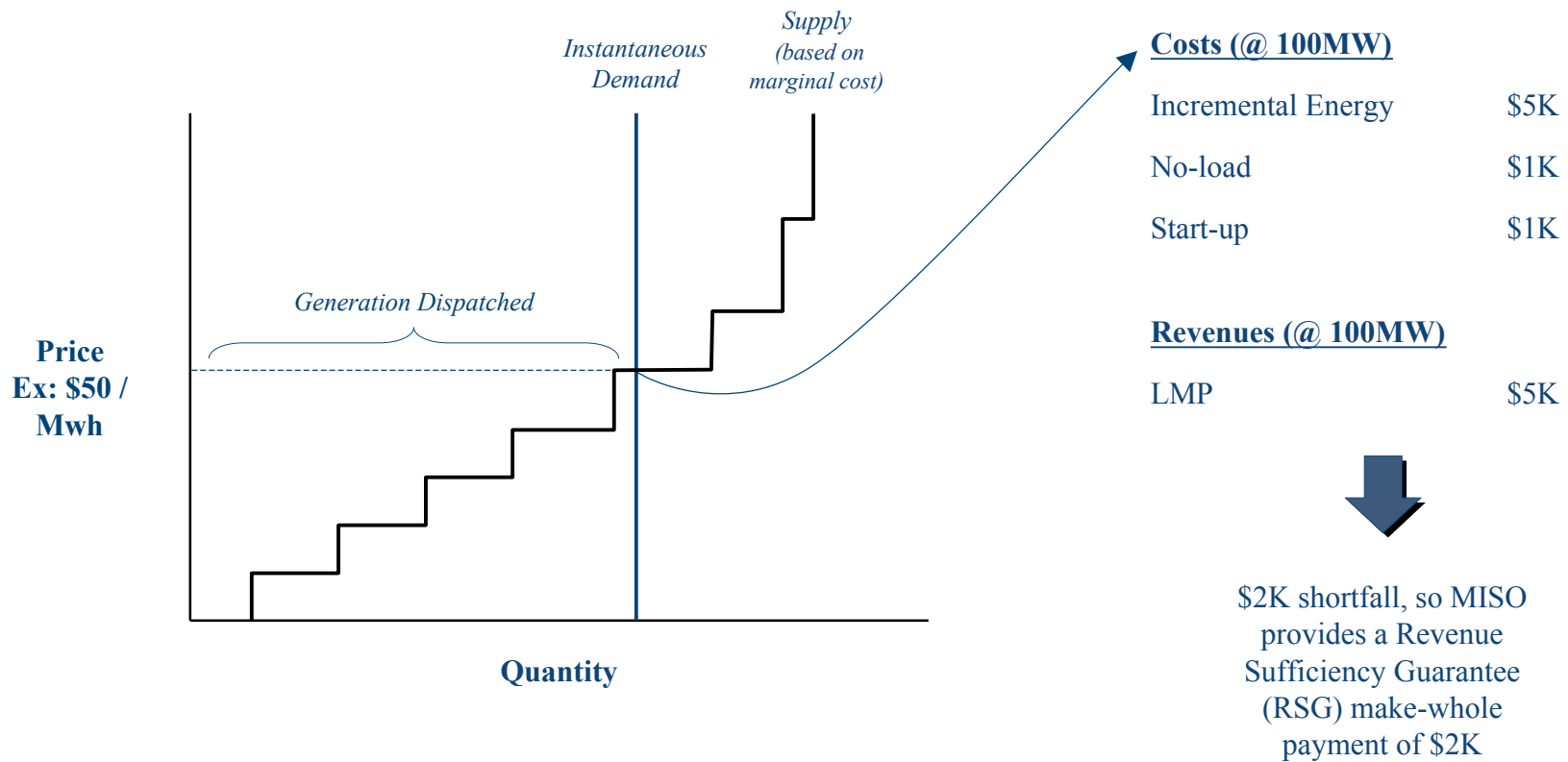
- *Layman's definition:* MISO pays generators a “make whole” payment to cover any revenue insufficiencies in the real time market. These amounts equal the difference between their total production “cost” (incremental energy + no-load + start-up bids) and real time energy revenues.
- *Allocation:* RSG has historically been allocated to generators, load, and exports (physical transactions) in proportion to their deviations from the Day Ahead Market, except that load/exports are allocated RSG only for Real-Time purchases that exceed Day-Ahead levels. The logic being that since these deviations generally cause RSG, they should pay for it.

RSG is often paid to generators who set the marginal clearing price, as LMP alone will not cover start-up and no-load costs

RSG Overview

Market Solution

Generator A Economics



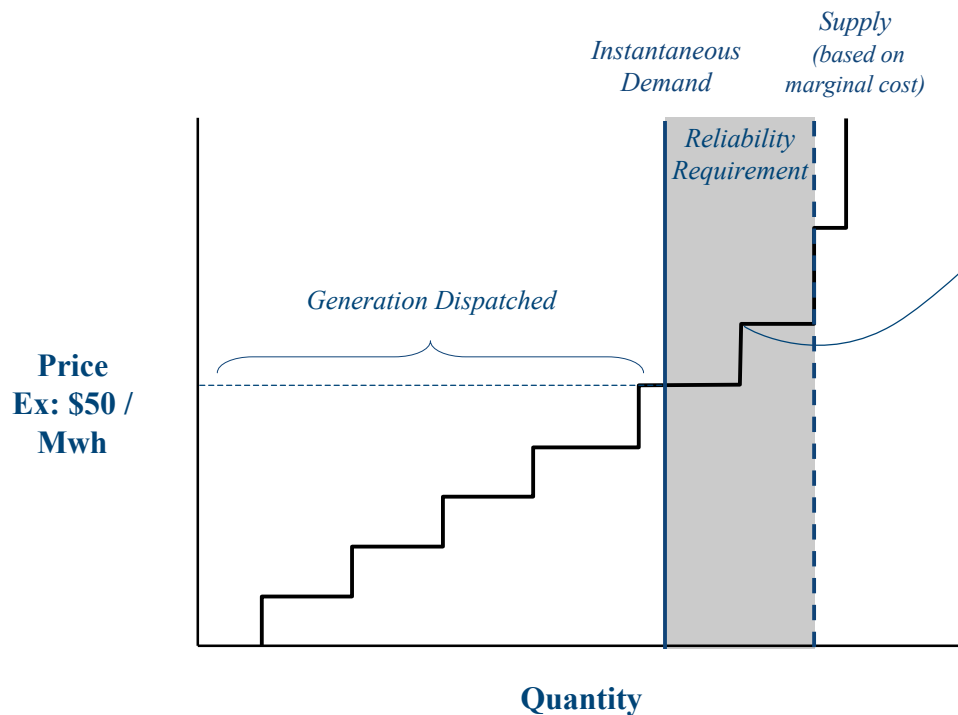
RSG is also often paid to generators committed for reliability / reserve purposes. In these cases LMP does not even cover incremental costs

RSG Overview (continued)

– Units committed for reliability / reserve purposes –

RAC Process to manage for reliability

Generator B Economics



Costs (@ 25 MW -- Eco Min Output)

Incremental Energy	\$1.5K
No-load	\$1.5K
Start-up	\$2K

Revenues (@ 25MW)

LMP	\$1.25K
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MISO pays this generator (committed for reliability)
 \$3.75K Revenue Sufficiency Guarantee (R&G) make-whole payment
 (Total RSG for Generators A and B is \$5.75k)

A FERC order on 4/25/06 suggested at least some portion of virtual offers will be charged RSG

FERC RSG Order Description

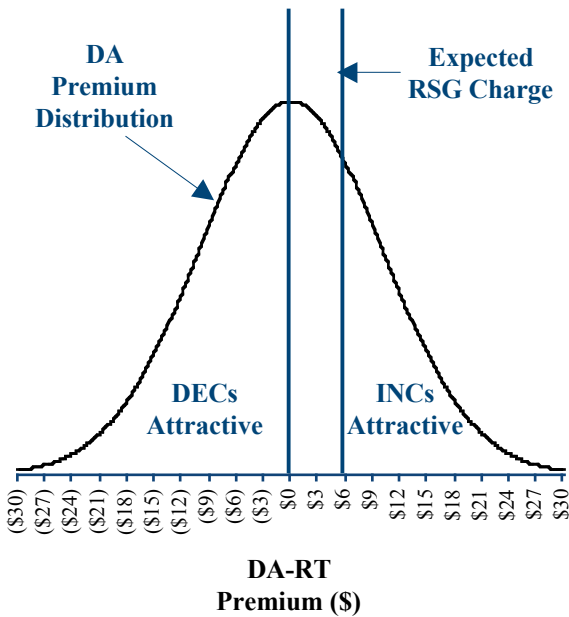
- **Since the first day of MISO market operations (4/1/05), MISO made it clear to market participants (via business practice manuals, training sessions, and actual settlement bills) that virtual offers were not subject to RSG charges**
- **MISO TEMT (energy market tariff), however, contained ambiguous wording regarding allocation of RSG charges to virtual offers, so MISO sought to clarify tariff wording to match intent (and filed changes with FERC)**
- **On April 25, 2006, FERC ruled that a subset of virtual transactions should be allocated RSG charges according to the letter of the law (in particular, those of participants who also withdraw energy in real-time)**
- **INC (Virtual offer) volume (and DEC volume to a lesser extent) subsequently declined dramatically (>50%)**
 - DA market premium increased
- **MISO requested a stay of implementation; some ambiguity still remains over which virtual offers will be charged, as well as how much they will be charged**

The steady state in an “INC RSG” world is one with a reduction in DECs, an even greater reduction in INCs, and a moderate DA premium

Post-RSG-Order Equilibrium Assessment
 – Example Case: RSG = \$6 –

Limiting Case (Unstable)

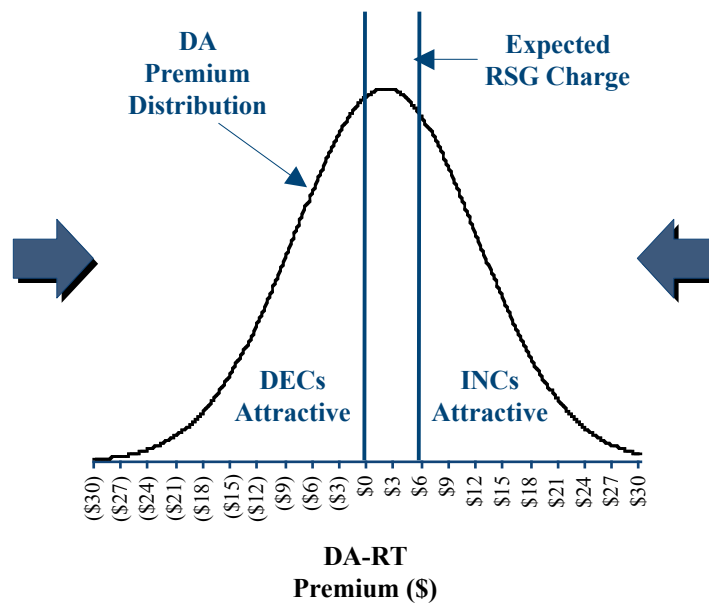
– INCs Reduced, DECs Unchanged, No DA Prem. –



The supply demand imbalance will naturally push the DA-RT distribution to the right (positive) side

Equilibrium

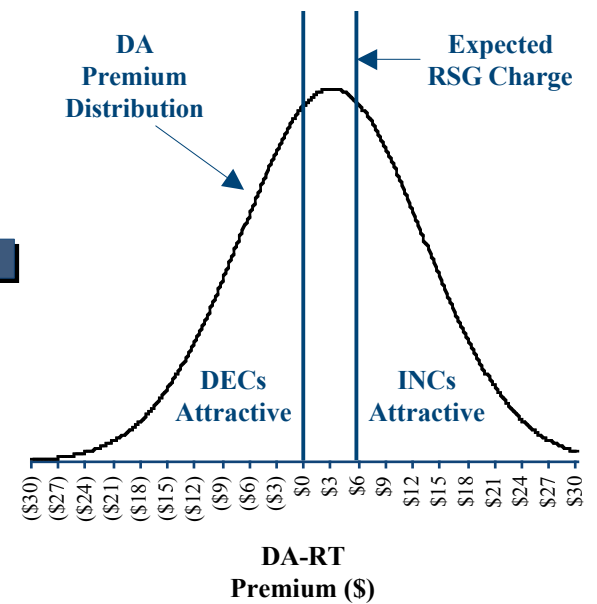
– DECs Reduced, INCs Reduced Further, Moderate DA Premium –



STEADY STATE

Limiting Case (Untenable)

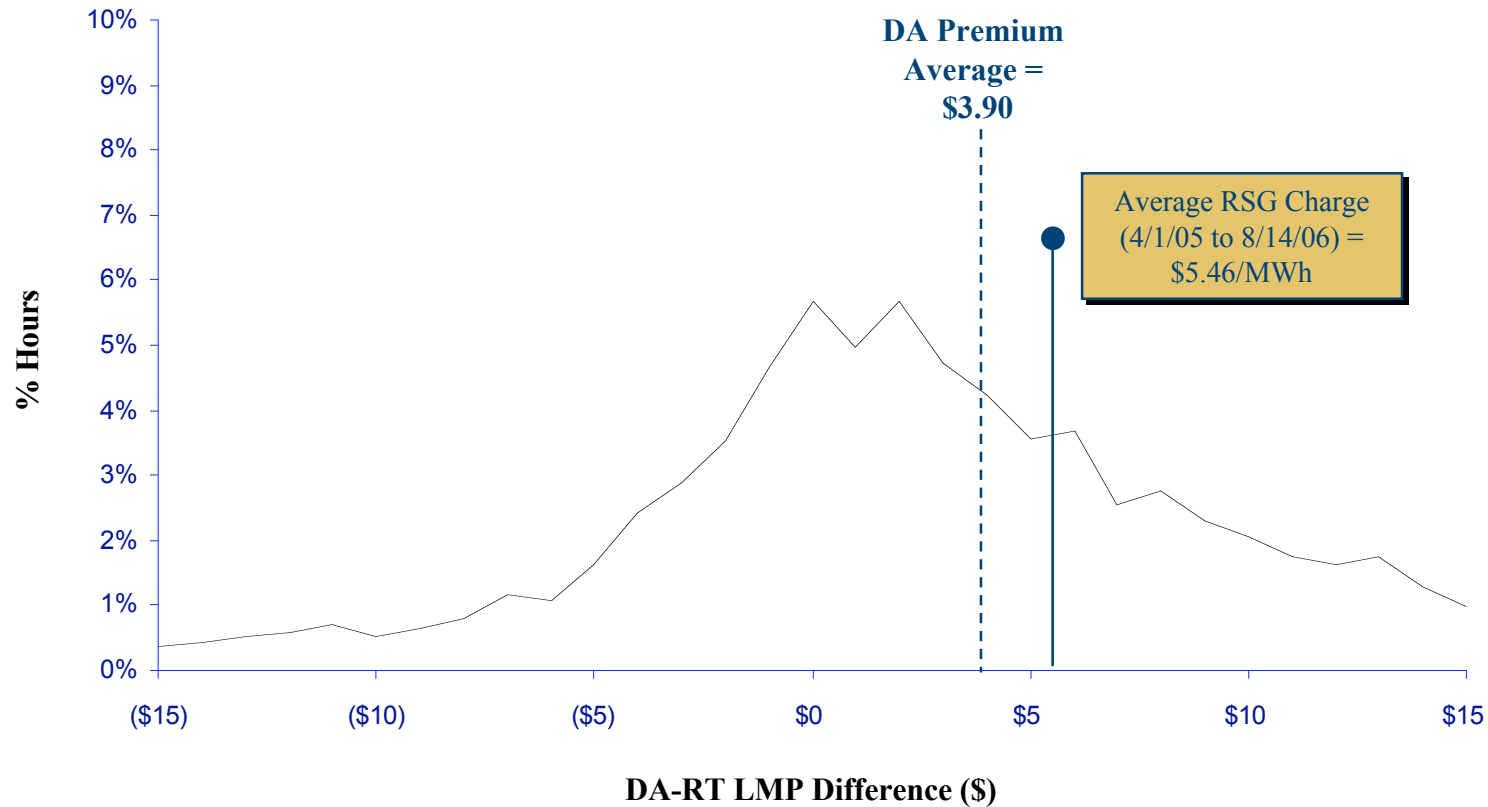
– INCs & DECs Equally Reduced, High DA Prem. –




The balance of supply and demand will naturally push the DA-RT distribution back towards zero

Looking at actual data, we do indeed see a moderate post-order DA premium that is somewhat less than the average RSG charge

Distribution of Hourly DA-RT LMP Difference at Cinergy Hub
– 4/27/06 to 8/14/06 –

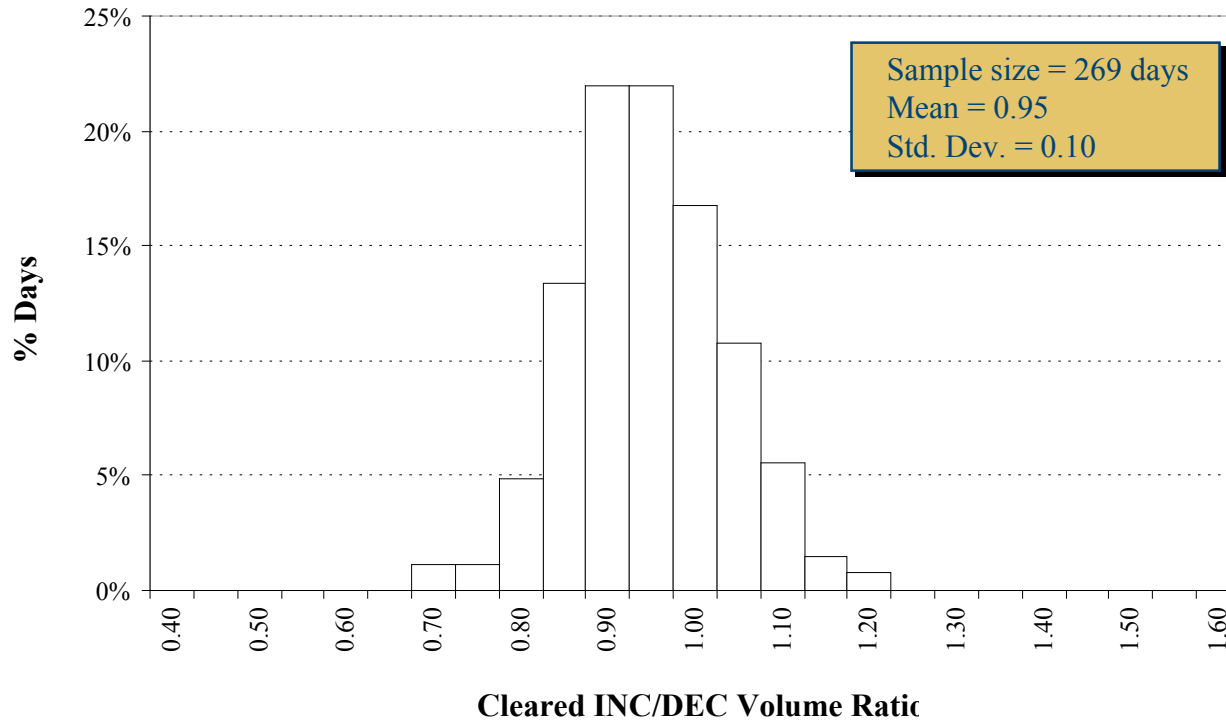


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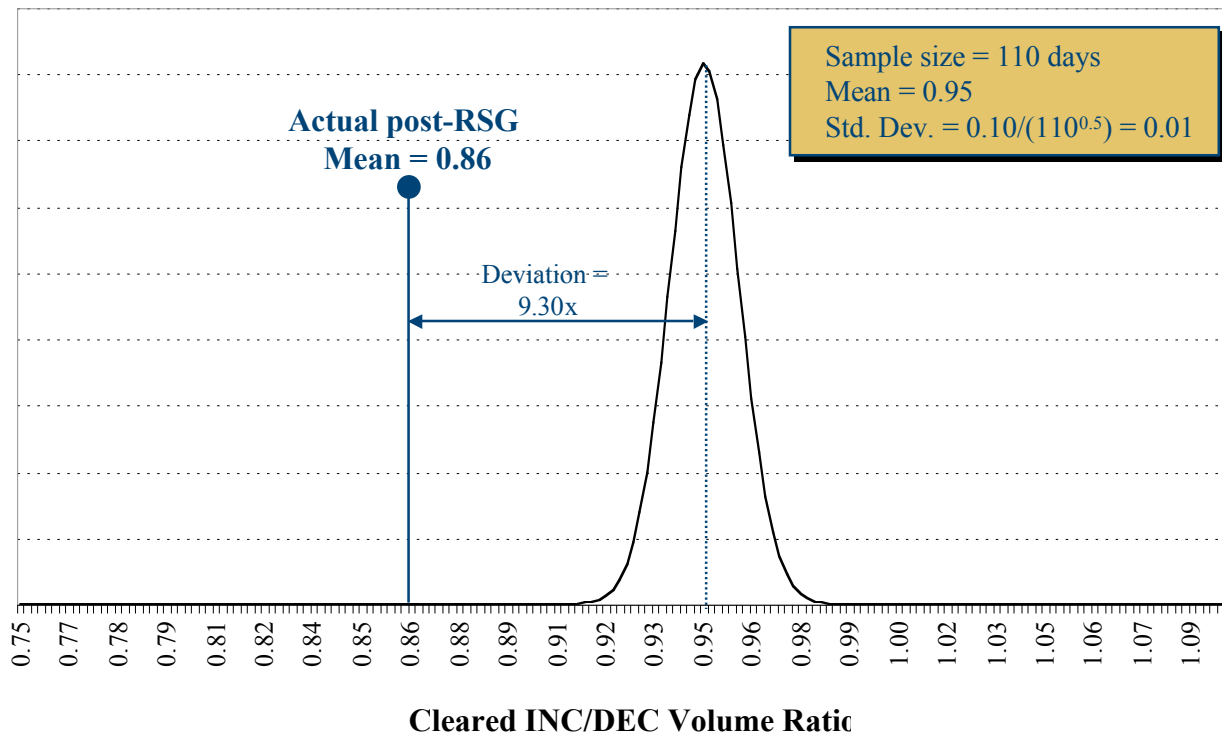
Prior to the FERC RSG order, average daily INC/DEC volume ratio was about 0.95, with a standard deviation of 0.10

Distribution of Cleared INC/DEC Volume Ratios
– 8/1/05 to 4/26/06 –



The post-RSG mean ratio is nine standard deviations away from where the simulated mean should be using pre-RSG data

Expected Distribution of the Mean of the INC/DEC Ratios Post-RSG Order
– 4/27/06 to 8/14/06 (raw data) –

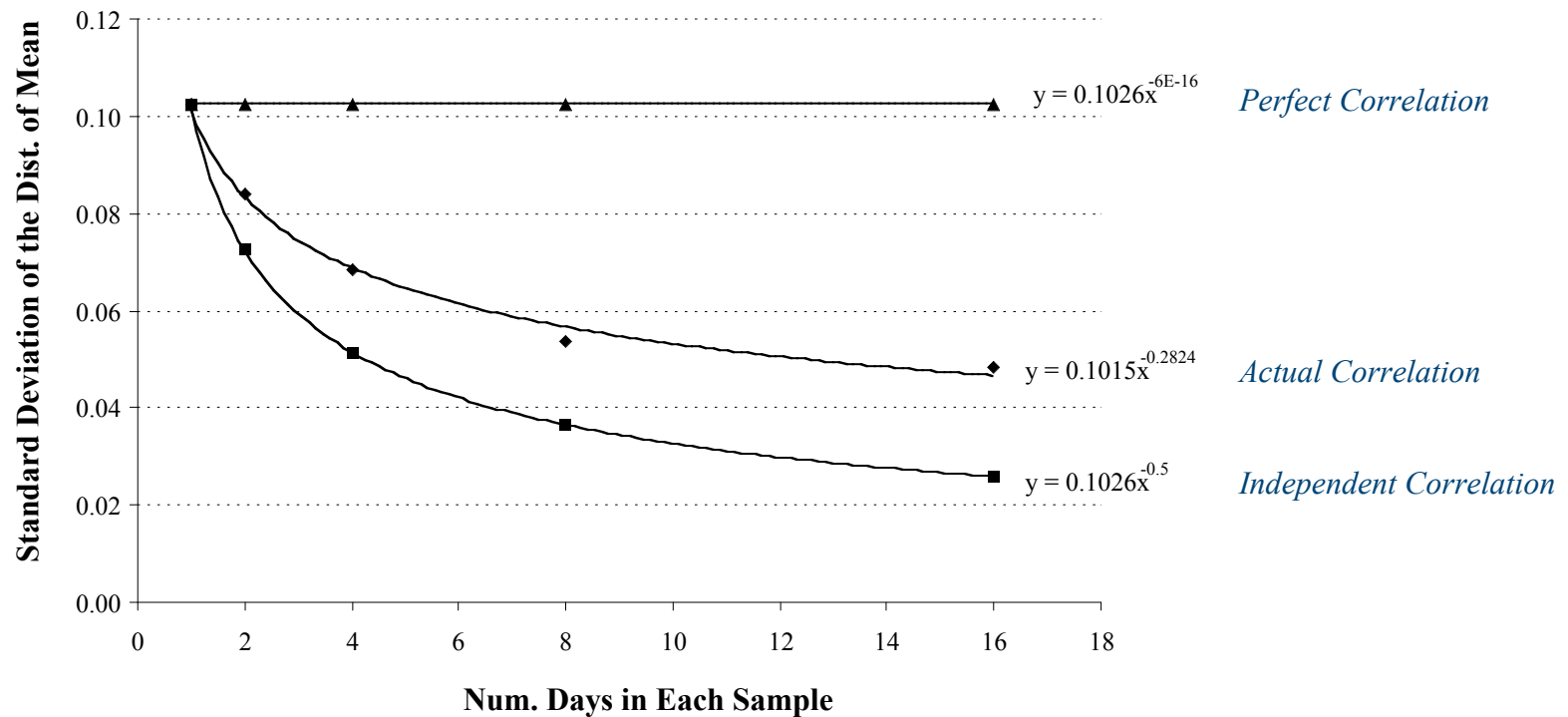


The actual post-RSG outcome is “off-the-charts” relative to what would have been expected in a pre-RSG world. The market has clearly been impacted.

However, the cleared INC/DEC ratio displays significant daily correlation which could artificially raise confidence intervals

Temporal Correlation Assessment of INC/DEC Ratios

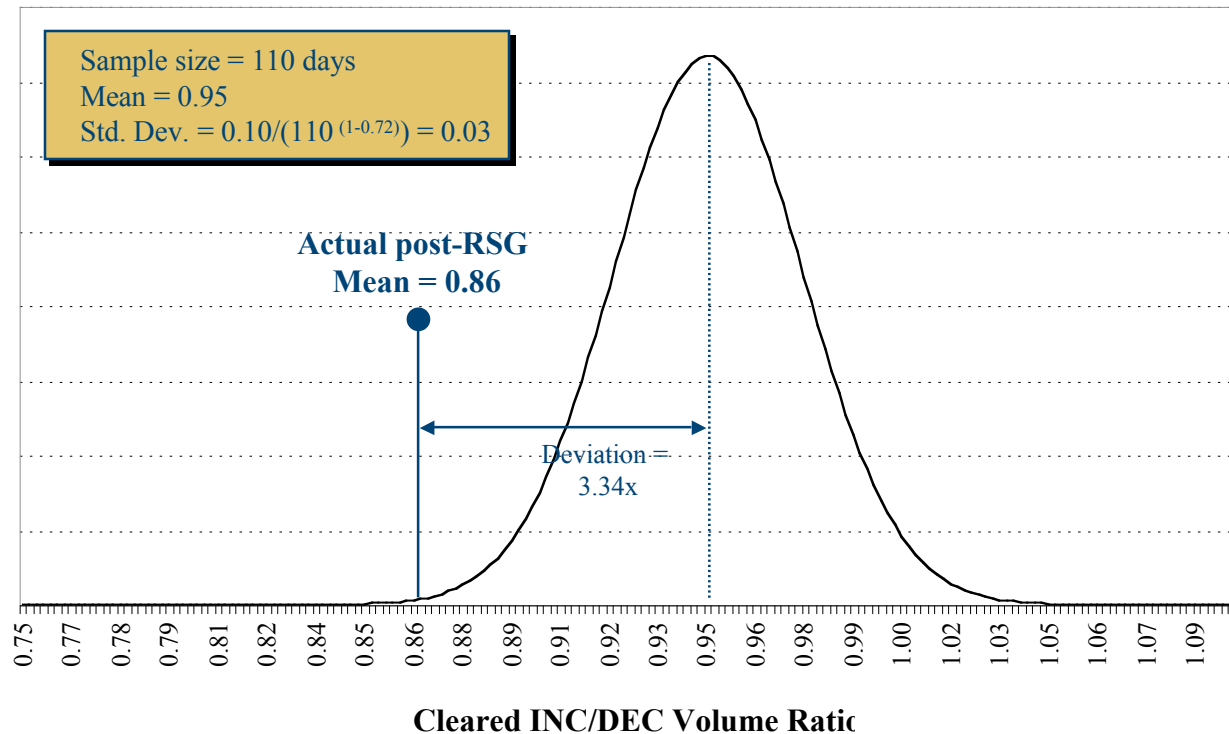
– 8/1/05 to 4/26/06 –



*Suggests a temporal correlation factor, $TCF = 1 - 0.28 = 0.72$
(midway between perfect & independent)*

Adjusting for correlation, the post-RSG mean ratio is still more than three standard deviations from the pre-RSG distribution

Expected Distribution of the Mean of the INC/DEC Ratios Post-RSG Order
– 4/27/06 to 8/14/06 (temporal correlation factor = 0.72) –



The RSG order caused a shift to a more DEC-heavy market; the natural implication is that the DA-RT premium should increase.

The ratio of INC to DEC has radically decreased post RSG

Summary of INC/DEC Volume Ratio Analysis – 8/1/05 to 8/14/06 –

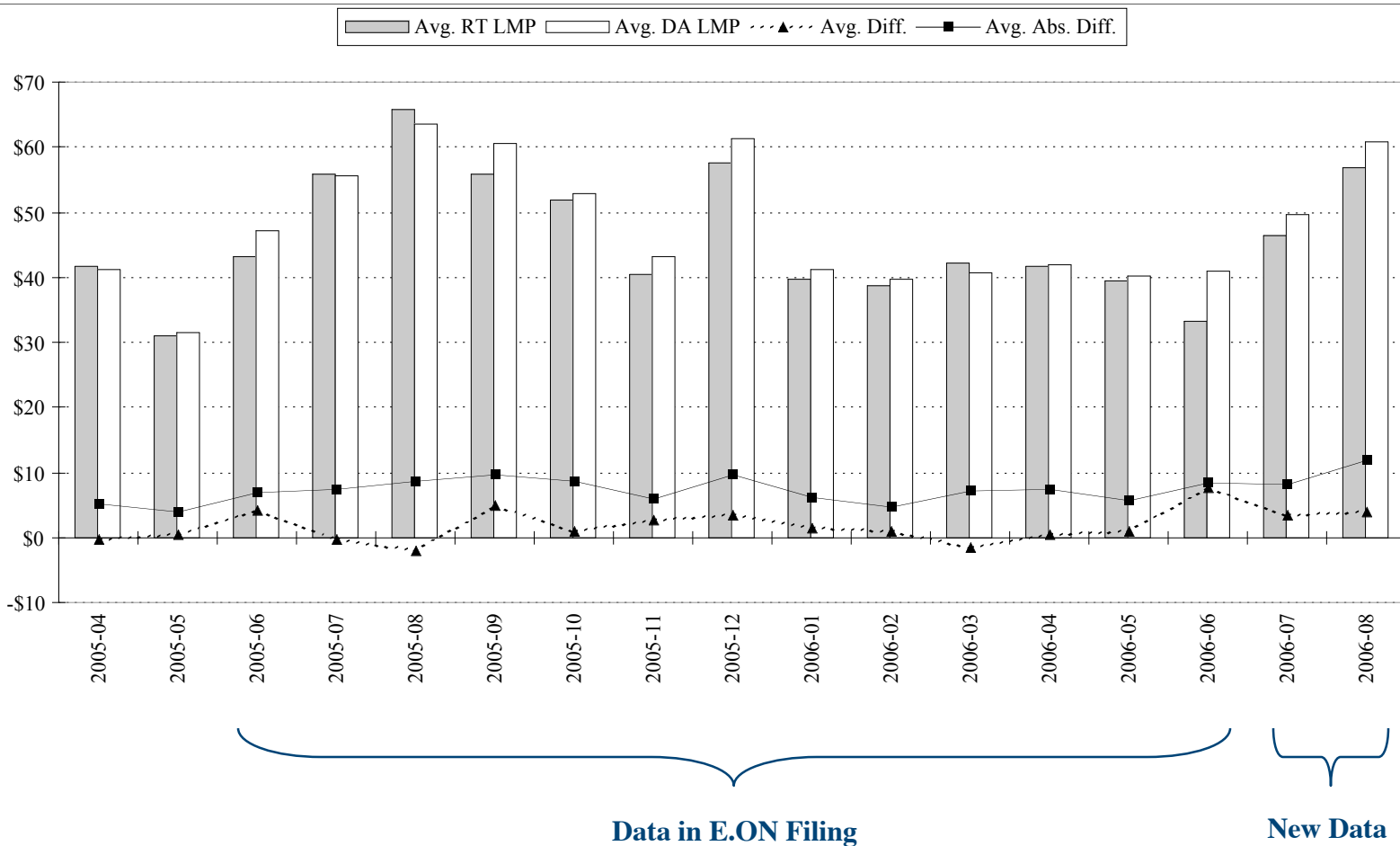
		INC-DEC Ratio	
Pre-RSG (8/1/05 - 4/26/06)	# days	269	
	μ	0.95	
	σ	0.10	
Post-RSG (4/27/06 - 8/14/06)	# days	110	
	μ	0.86	
	σ	0.29	
Post-RSG decrease in μ		0.09	
TCF =	0.50	Post-RSG expected σ	0.01
		Post-RSG decrease in μ (as multiple of σ)	9.30
		Confidence	100.00%
TCF =	0.72	Post-RSG expected σ	0.03
		Post-RSG decrease in μ (as multiple of σ)	3.34
		Confidence	99.96%

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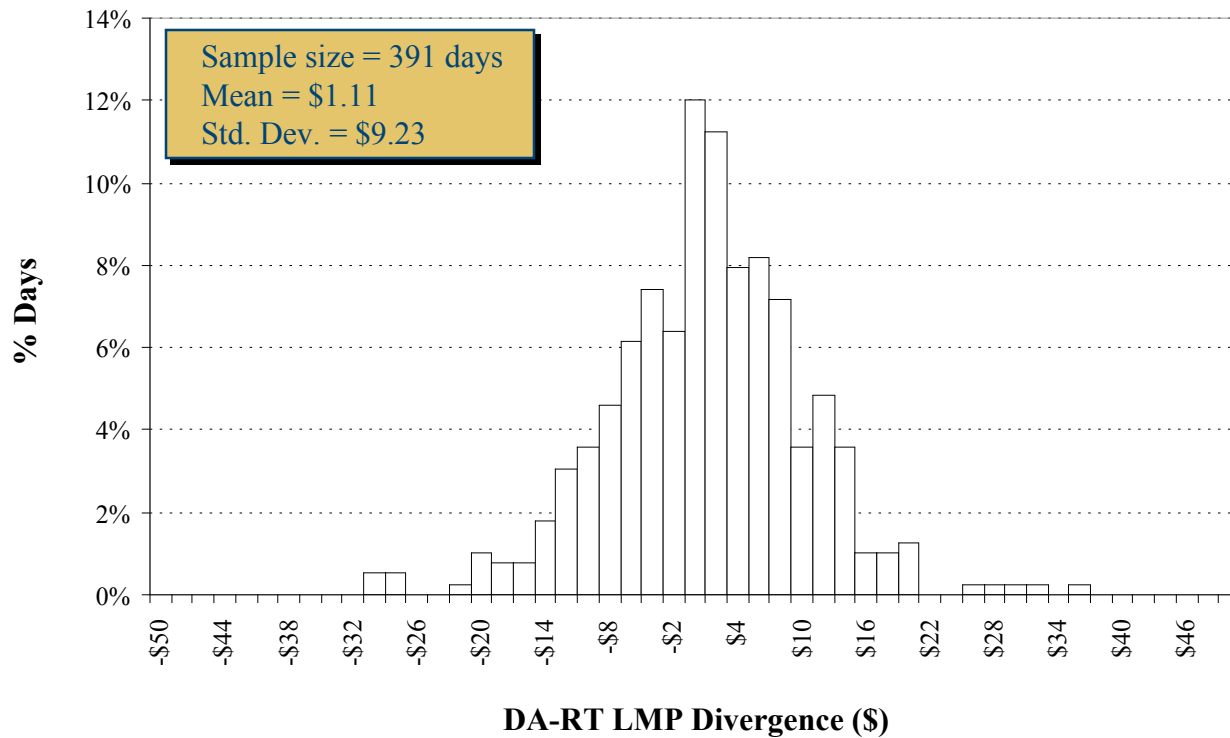
Looking at monthly averages suggests that the DA premium has risen, although one cannot quantitatively test the hypothesis that it has risen

DA-RT Monthly Averages



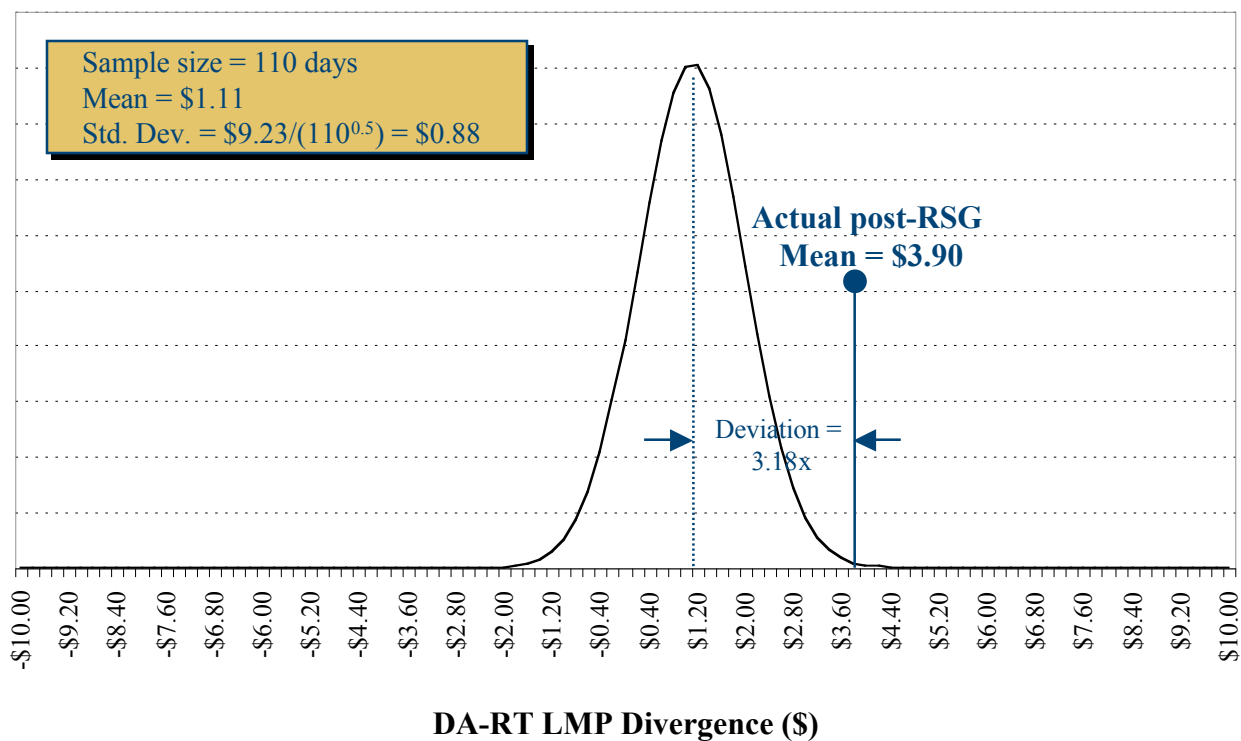
However, we can perform another statistical assessment – this time of the average daily DA-RT premium

Distribution of DA-RT Power Price Premium at Cinergy Hub
– 4/1/05 to 4/26/06 –



Statistical analysis again shows that the post-RSG world is different than before: the \$2.80 increase in the DA premium is significant

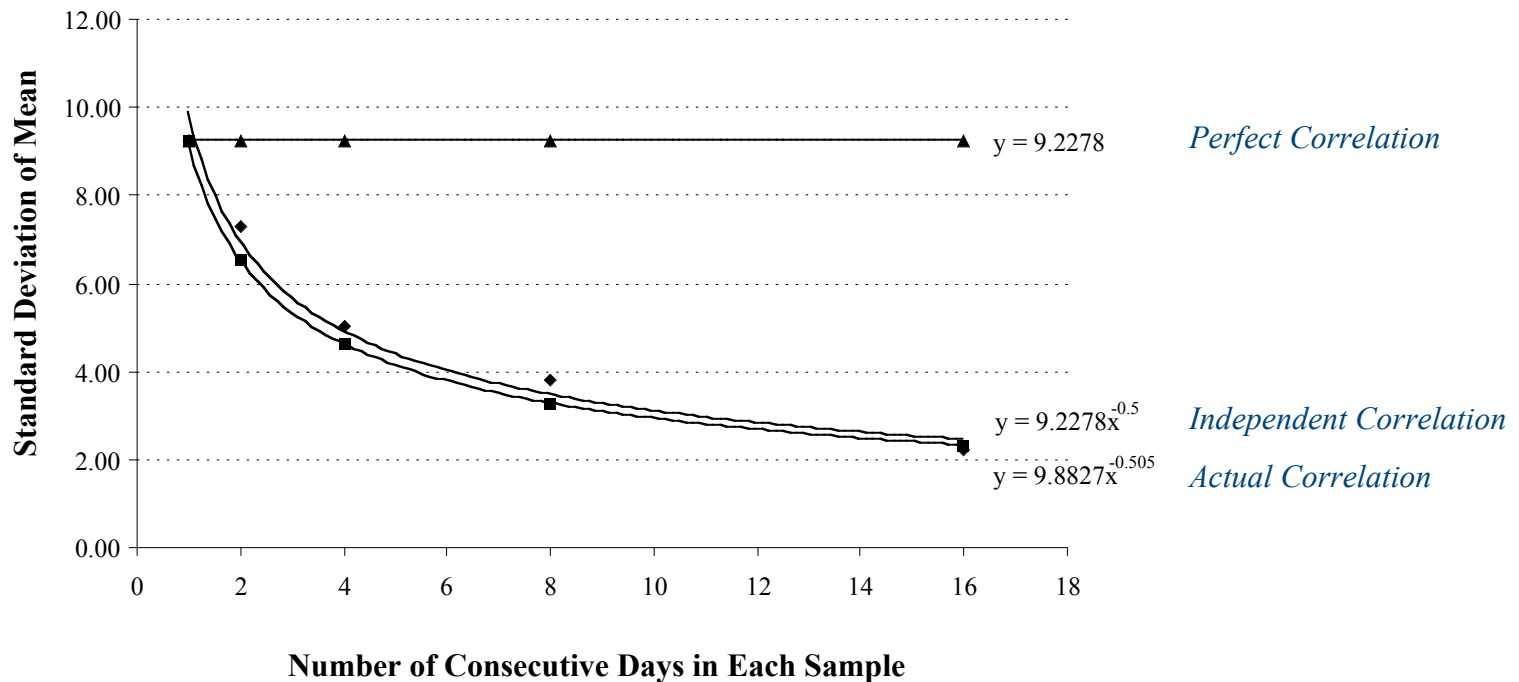
Expected Distribution of the Mean of the DA Premium Post-RSG Order
– Cinergy Hub, 4/27/06 to 8/14/06 (complete independence assumed) -



Note: The average RT price was actually lower in the post-RSG period than the pre-RSG period, which makes the significance even greater than it appears.

The average daily DA-RT market premium is not correlated from one day to the next at the Cinergy Hub

Temporal Correlation Assessment of DA-RT Premium
– Cinergy Hub, 4/1/05 to 4/26/06 –



A lack of daily correlation suggests that the statistical significance of the analysis need not be adjusted

Expanding this analysis to the other major MISO hubs shows the same general result

DA-RT Premium for Four Major Hubs – 4/1/05 to 4/26/06 –

		CINERGY HUB	ILLINOIS HUB	MICHIGAN HUB	MINNESOTA HUB	
Pre-RSG (4/1/05 - 4/26/06)	# days	391	391	391	391	
	μ	1.11	1.23	0.95	1.62	
	σ	9.23	9.69	10.03	14.79	
Post-RSG (4/27/06 - 8/14/06)	# days	110	110	110	110	
	μ	3.90	2.39	3.27	3.92	
	σ	9.34	14.23	11.27	19.85	
Post-RSG increase in μ		\$ 2.80	\$ 1.16	\$ 2.31	\$ 2.30	Avg: \$2.14
		Assuming Independence (TCF = 0.5)				
Post-RSG expected σ		0.88	0.92	0.96	1.41	
Post-RSG increase in μ (as multiple of σ)		3.18	1.25	2.42	1.63	
Confidence		99.93%	89.50%	99.22%	94.84%	
Computed TCF		0.50	0.49	0.52	0.56	
		Using Computed TCFs				
Post-RSG expected σ		0.86	0.90	1.04	1.86	
Post-RSG increase in μ (as multiple of σ)		3.25	1.29	2.23	1.24	
Confidence		99.94%	90.12%	98.71%	89.22%	

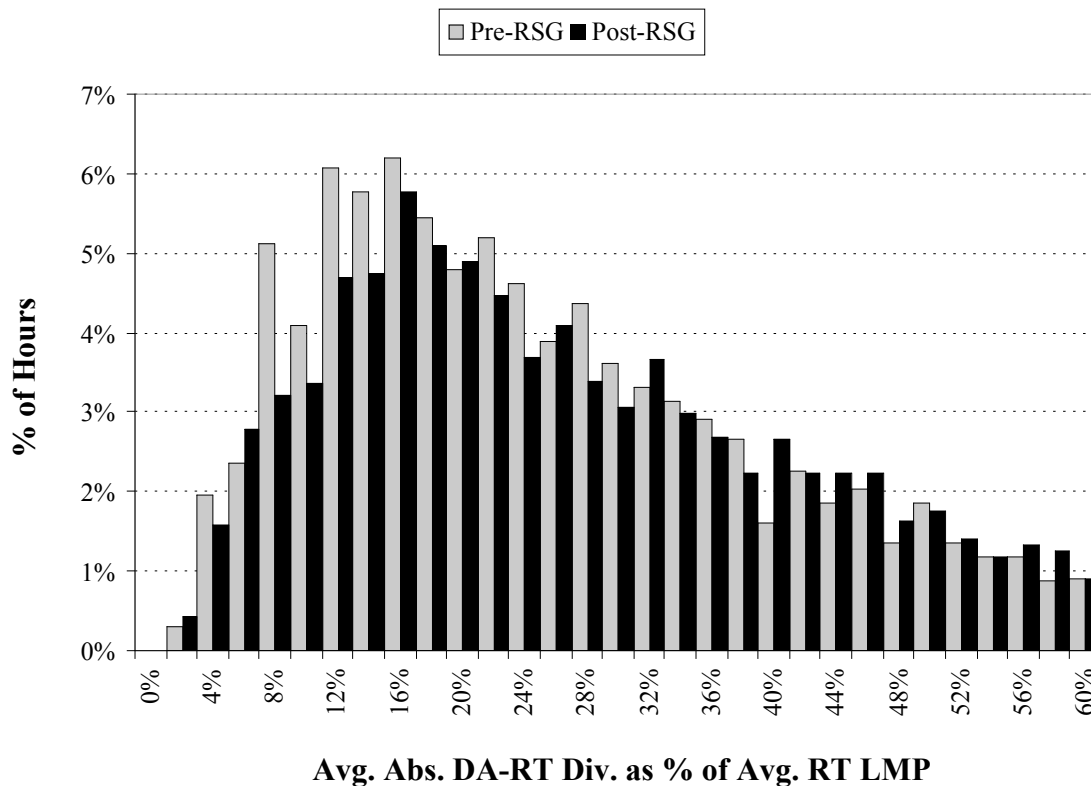
The average increase in the DA premium for the four hubs is \$2.14.

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Average absolute hourly DA-RT power price divergence has a log-normal distribution, with a 30% pre-RSG mean vs. 36% post-RSG

Distribution of Average Absolute Hourly DA-RT Power Price Divergence – All nodes, 1/1/06 to 8/14/06 –

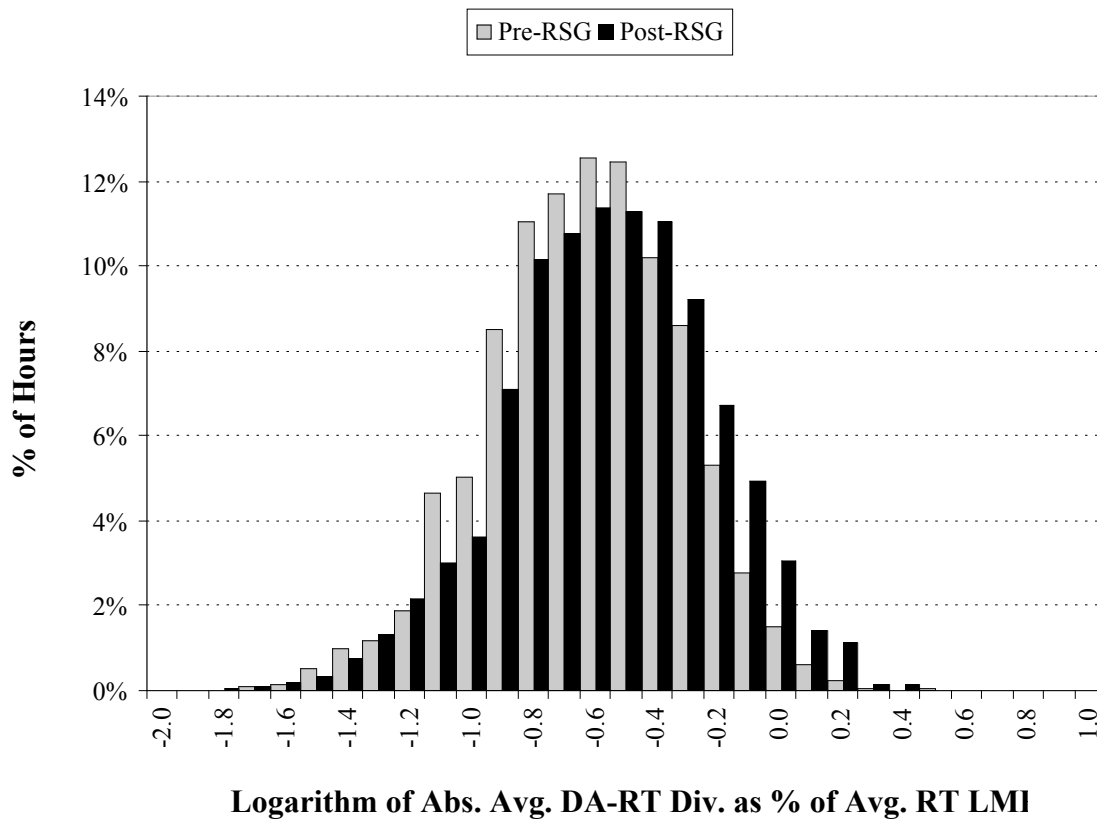


Pre-RSG (1/1/06 - 4/26/06)	
# hours	2762
μ	30%
σ	0.22

Post-RSG (4/27/06 - 8/14/06)	
# hours	2586
μ	36%
σ	0.30

If the previous distribution is normalized using a log function, it is easier to observe the post-RSG shift in the mean

Distribution of Log. of Average Absolute DA-RT Power Price Divergence
 – All nodes, 1/1/06 to 8/14/06 –



Pre-RSG (1/1/06 - 4/26/06)	
# hours	2762
μ	-0.63
σ	0.31

Post-RSG (4/27/06 - 8/14/06)	
# hours	2586
μ	-0.56
σ	0.34

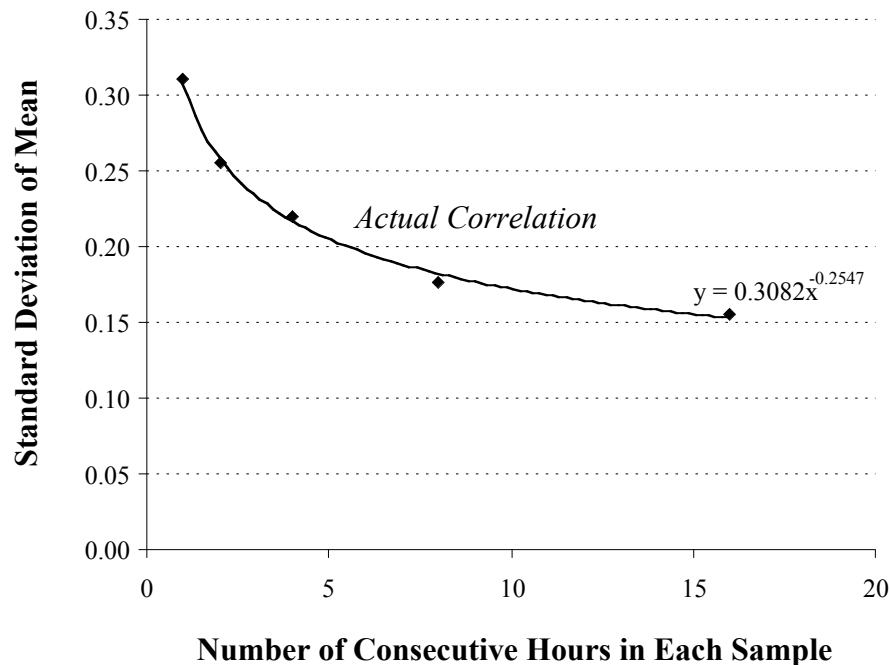
Adjusting for hourly correlation lowers the confidence that the post-RSG change in the mean divergence, but it is still statistically significant

Hourly Correlation and Statistical Significance

– All nodes, 1/1/06 to 8/14/06 –

Temporal Correlation Assessment

– 1/1/06 to 4/26/06 –



Statistical Assessment

Pre-RSG (1/1/06 - 4/26/06)	
# hours	2762
μ	-0.63
σ	0.31

Post-RSG (4/27/06 - 8/14/06)	
# hours	2586
μ	-0.56
σ	0.34

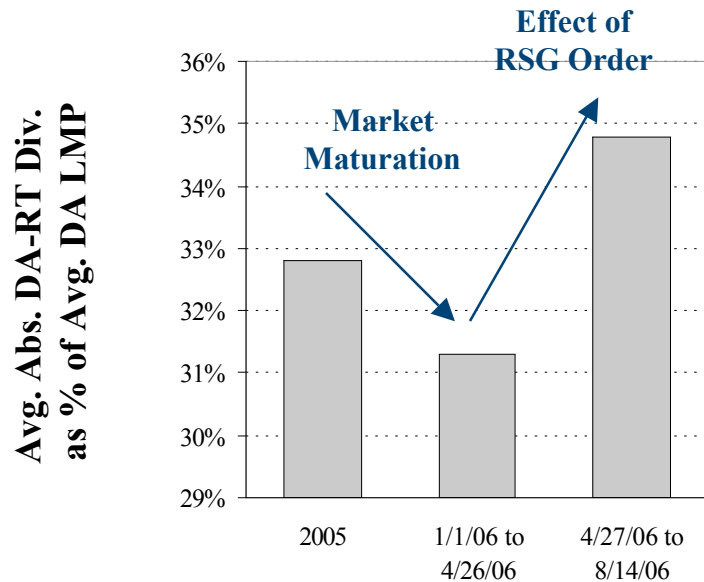
Post-RSG increase in μ	0.06
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Assuming independence (TCF = 0.5)	
Post-RSG expected σ	0.01
Post-RSG decrease in μ (as multiple of σ)	10.46
Confidence	100.00%

Using actual TCF = 0.75	
Post-RSG expected σ	0.05
Post-RSG decrease in μ (as multiple of σ)	1.40
Confidence	91.98%

A top-level approach using raw absolute deviation also confirms that the post-RSG divergence is higher than it was in 2005 and pre-RSG 2006

Average Absolute DA-RT Power Price Divergence – All nodes, 4/1/05 to 8/14/06 –



	Pre-RSG (1/1/06-4/26/06)	Post-RSG (4/27/06-8/14/06)
Avg. Abs. Divergence	\$ 12.80	\$ 16.76
Avg. DA LMP	\$ 40.89	\$ 48.19
Avg. RT LMP	\$ 41.45	\$ 44.70
Divergence as % of DA LMP	31%	35%
Divergence as % of RT LMP	31%	37%

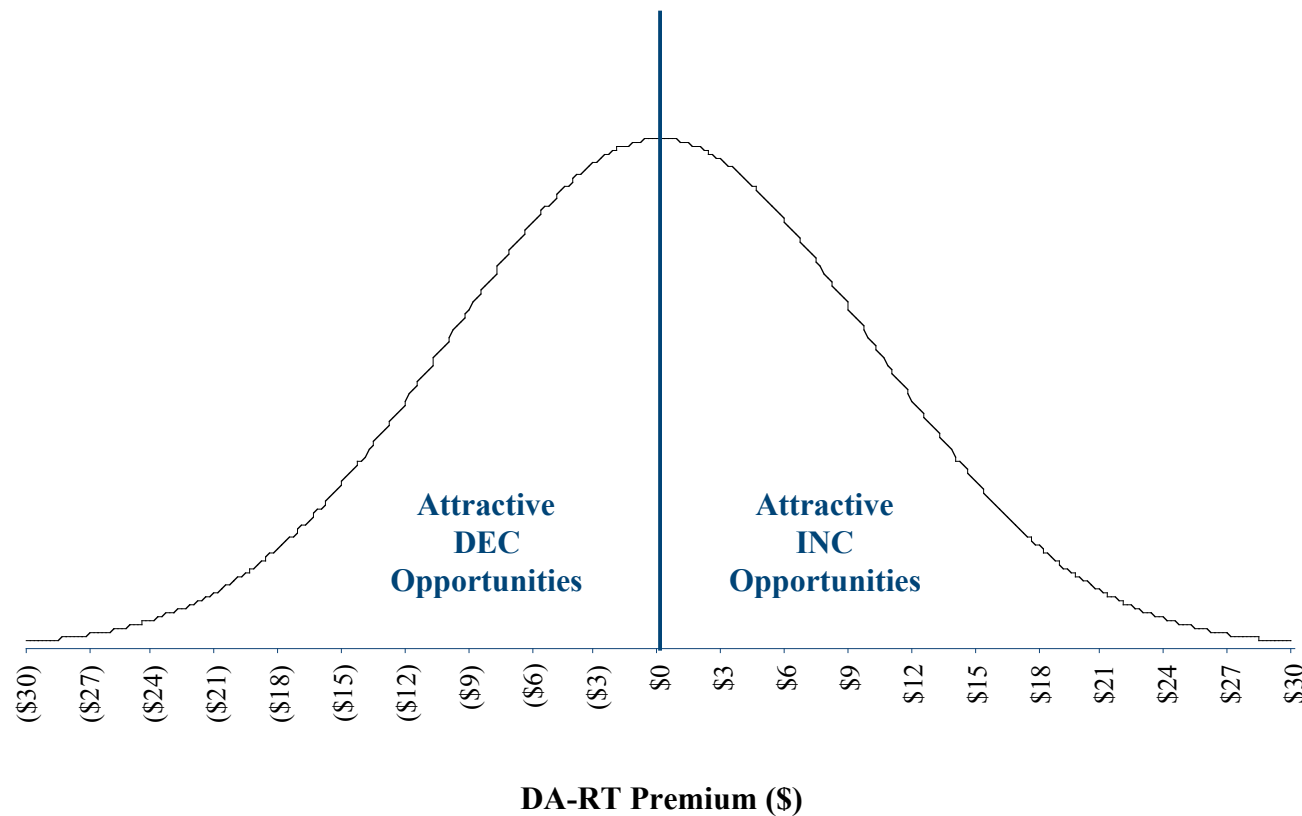
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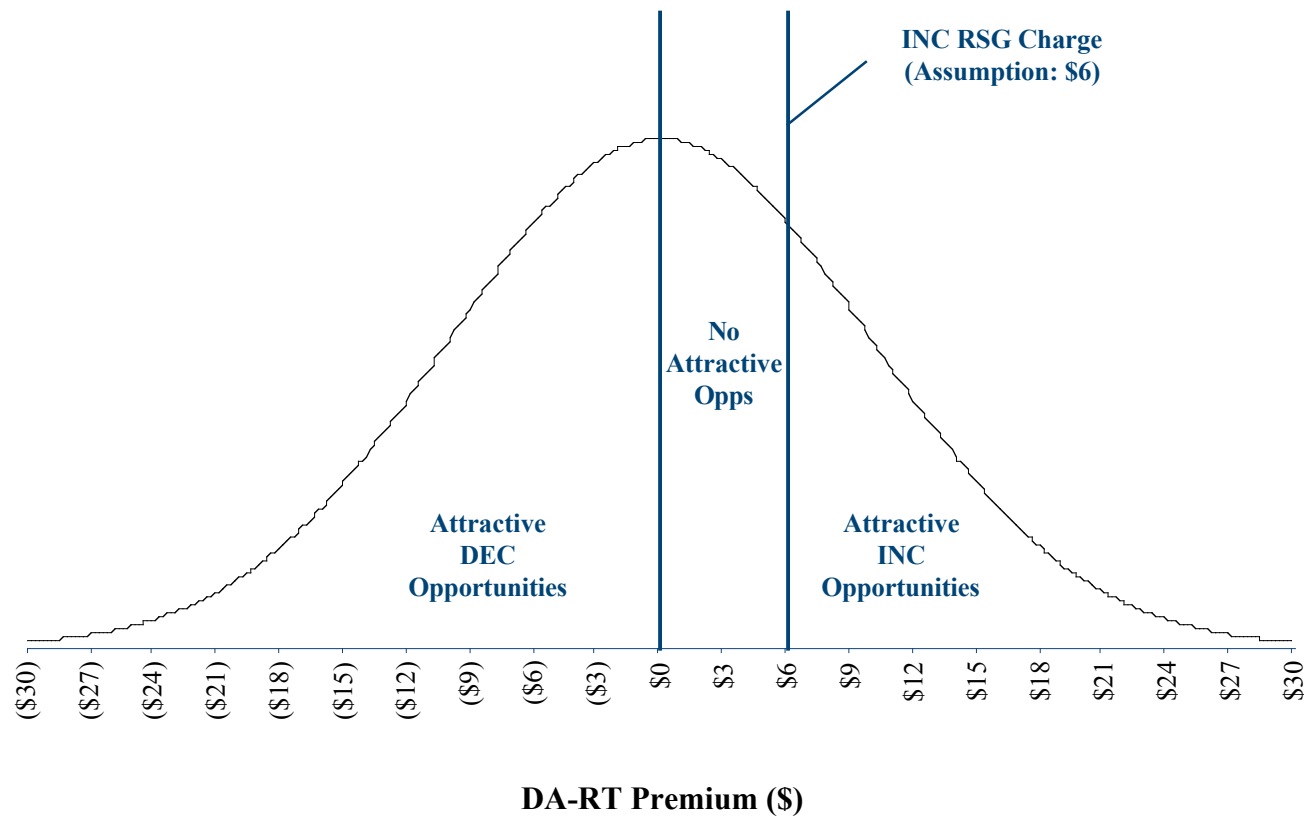
The distribution of DA-RT deviations is roughly normal with a mean near zero -- which in a normally functioning market with no RSG means roughly equal opportunities for INCs (virtual supply) and DEC (virtual demand)

Distribution of DA-RT Deviations
– Attractive INCs / DEC Assuming No RSG Charge –



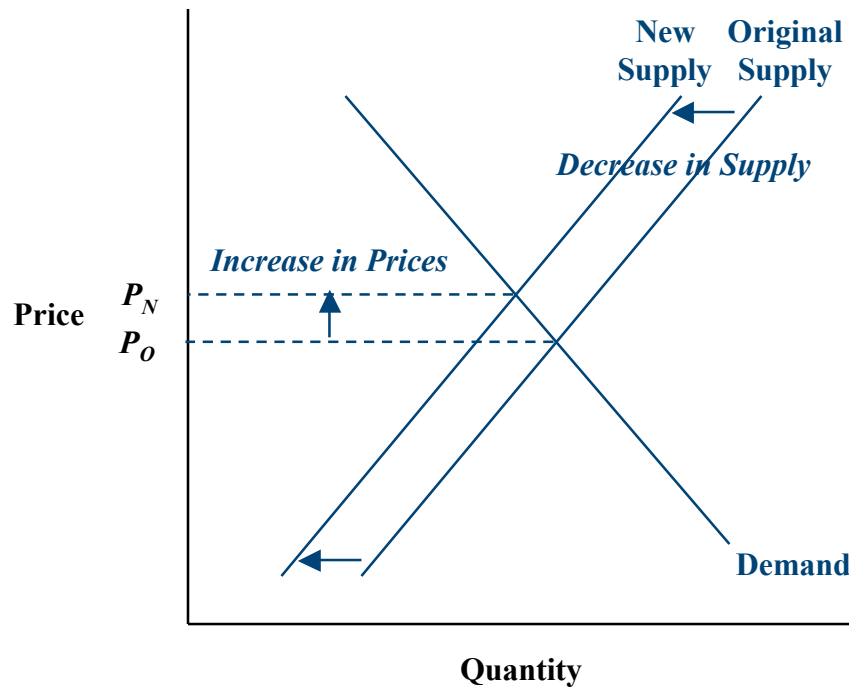
The introduction of a charge on INCs (Virtual Offers) makes some subset of those opportunities unattractive

Immediate Effect of RSG Charge on Attractive Virtual Opportunities



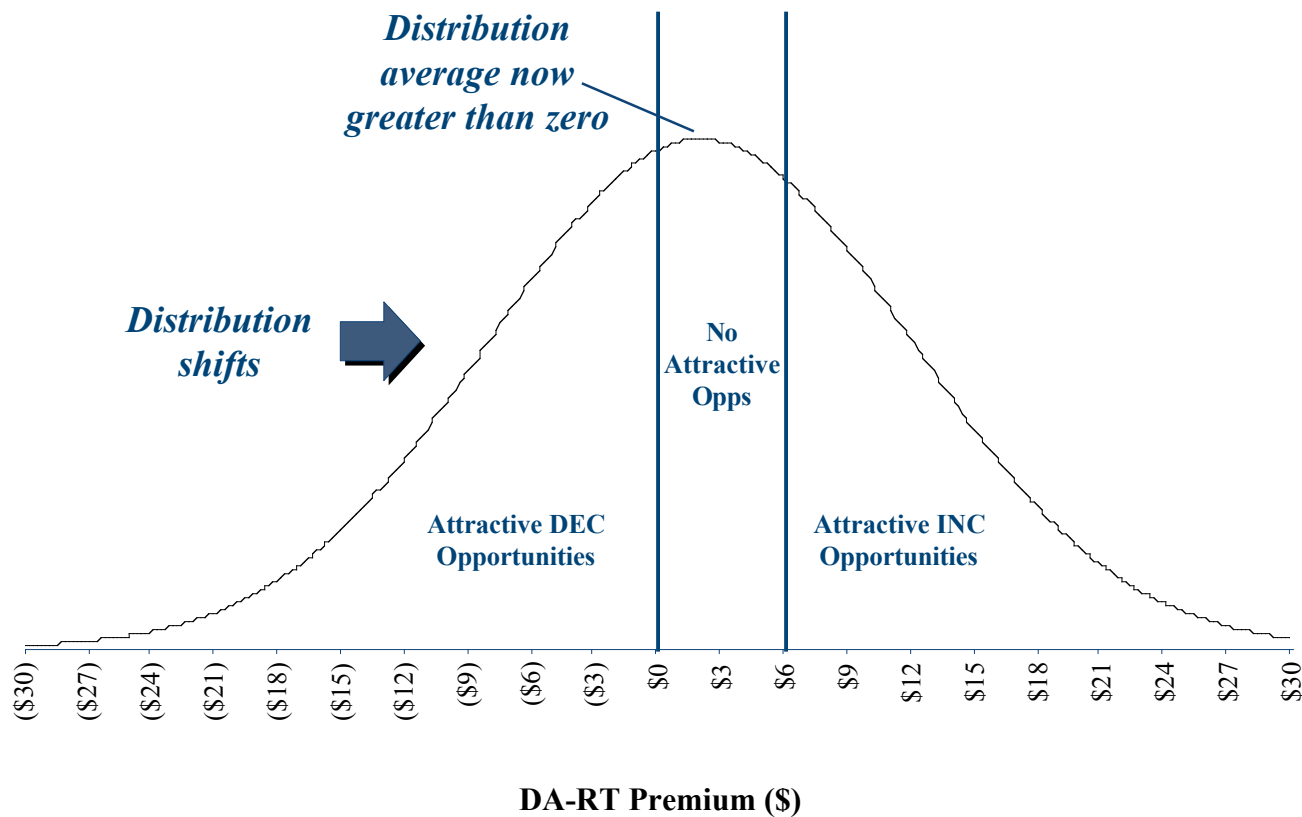
As INCs (Virtual Offers) withdraw from the market, a DA premium develops...

Impact of INC Withdrawal on DA Market



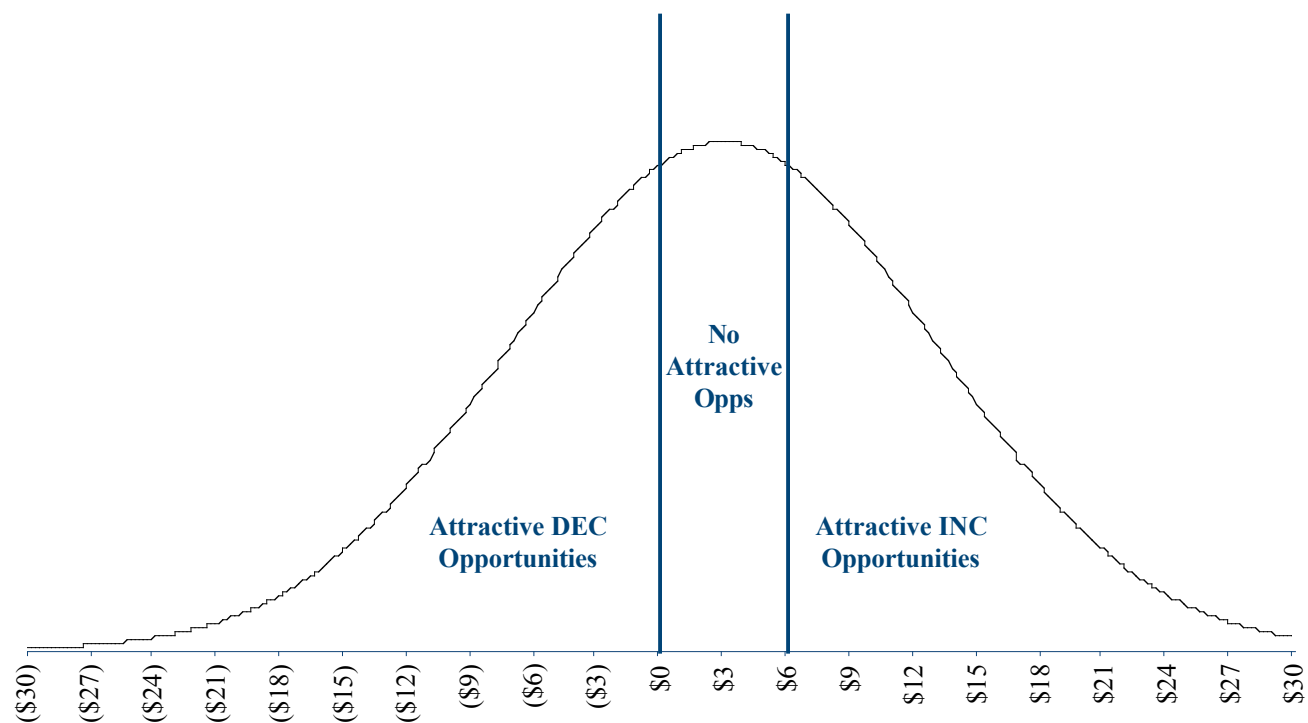
... and shifts the distribution of DA-RT deviations to the right (positive) side -- which means fewer DEC opportunities, and a modest rebound in INC opportunities (levels still below the DEC side)

Effect of RSG Charge on Attractive Virtual Opportunities – Steady State Balance –



Note that the distribution does not shift so much that the number of attractive INCs and DECAs balance out. If this were the case, then there would be nothing left to support the DA-RT shift (as there would be no supply/demand imbalance)

Example of Untenable DA-RT Distribution Shift
– “Limiting Case” for DA Premium Increase –



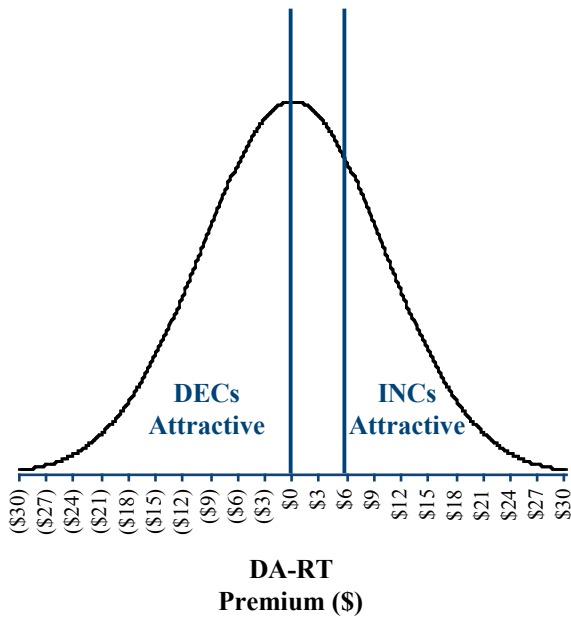
Note: Implies a theoretical cap on the DA premium of half the RSG charge (\$3 in this illustrative example where RSG has been assumed to be \$6)

The steady state in an “INC RSG” world is one with a reduction in DECs, an even greater reduction in INCs, and a moderate DA premium

Post-RSG-Order Equilibrium Assessment

Limiting Case (Unstable)

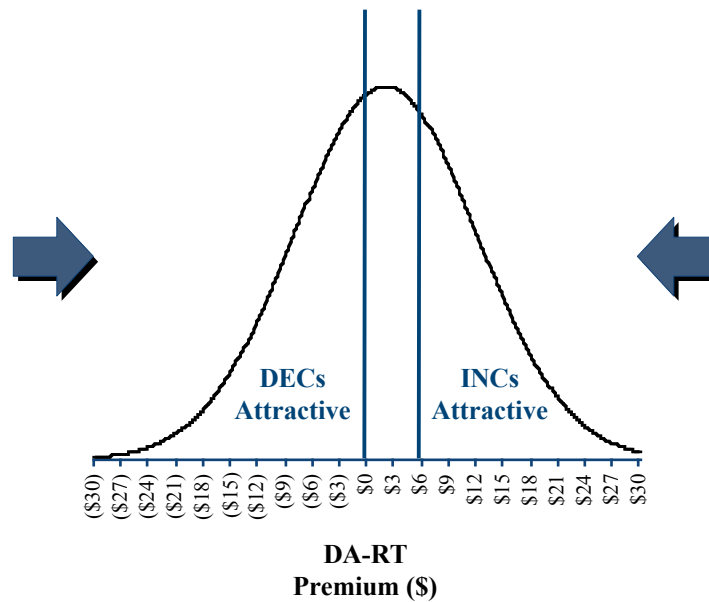
– INCs Reduced, DECs Unchanged, No DA Prem. –



The supply demand imbalance will naturally push the DA-RT distribution to the right (positive) side

Equilibrium

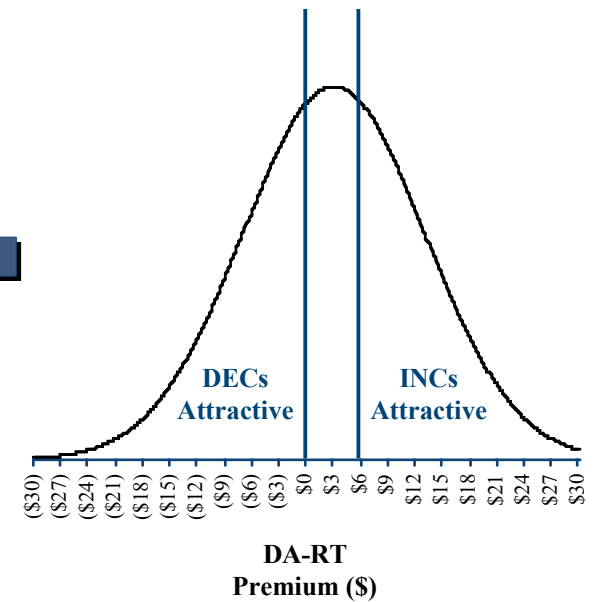
– DECs Reduced, INCs Reduced Further, Moderate DA Premium –



STEADY STATE

Limiting Case (Untenable)

– INCs & DECs Equally Reduced, High DA Prem. –



The balance of supply and demand will naturally push the DA-RT distribution back towards zero

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 - Convergence in Other ISO Markets

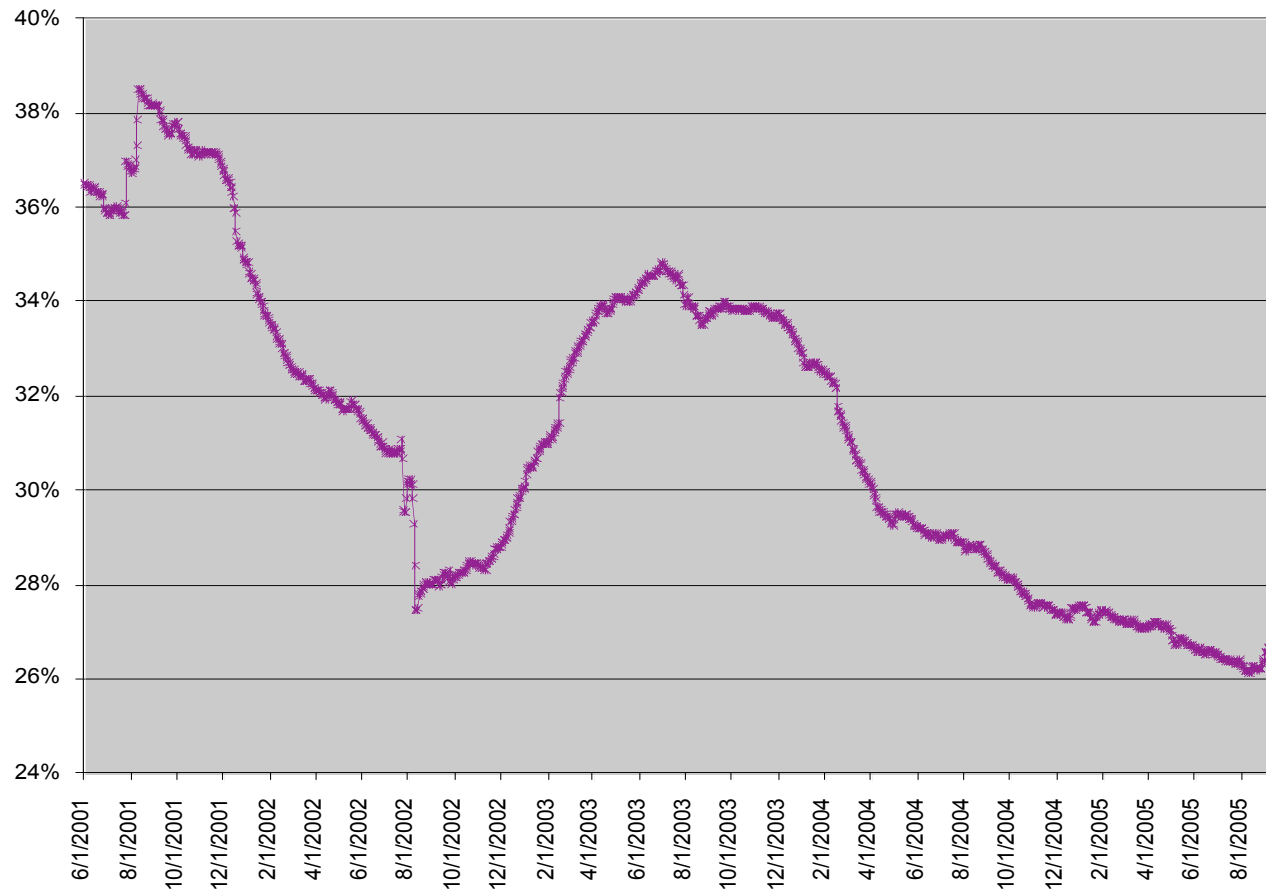


A simple metric suggests that convergence has improved substantially over time, with disruptions during the assimilation of new geographies

Convergence Metric: PJM Example

Ratio of Avg. Abs. Spread to Avg. DA Price (1 Yr Lookback)

Average Hourly Absolute Nodal Spread as Percent of Average DA Power Price¹

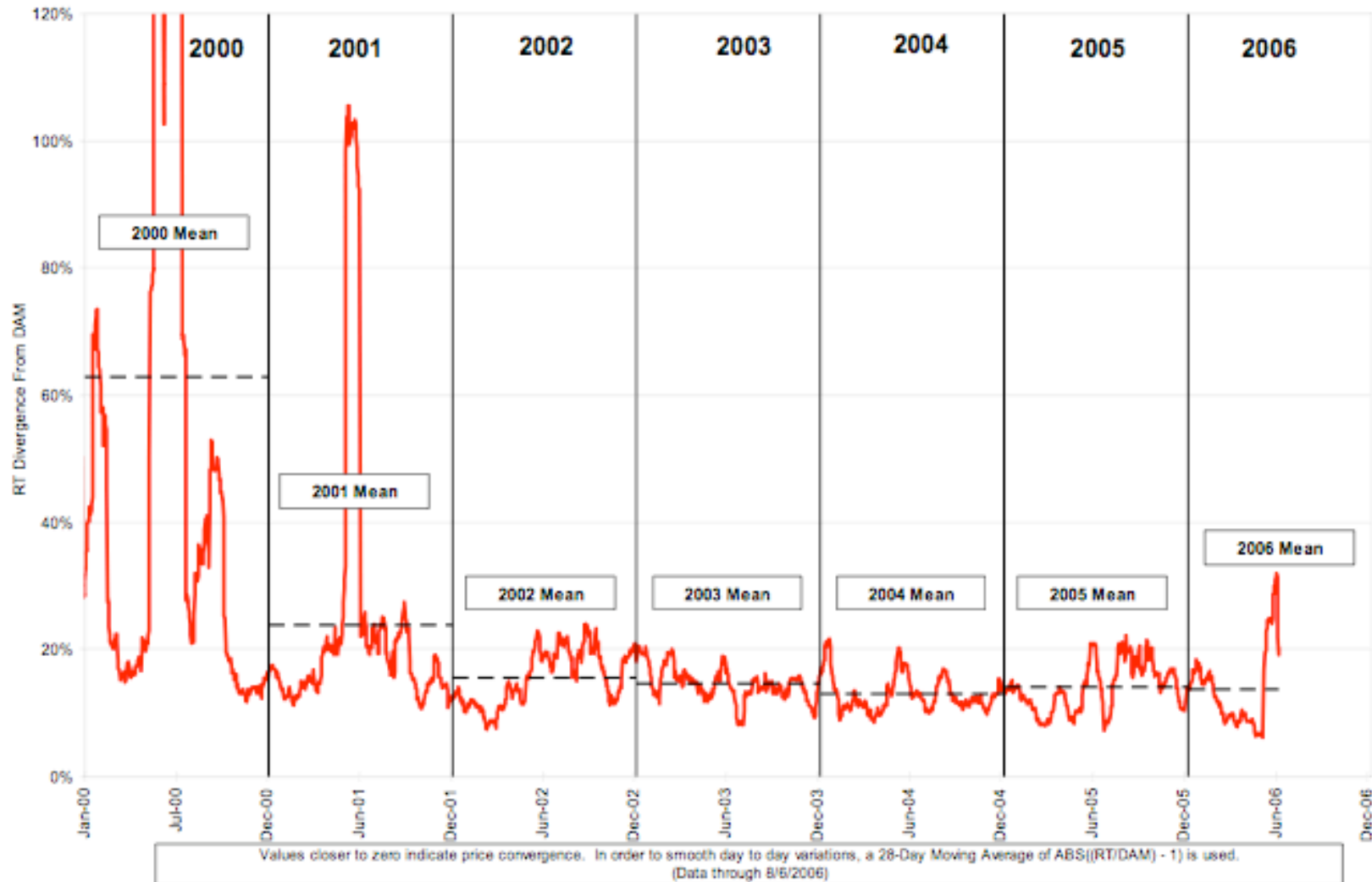


¹ Data set starts 06/01/00 and ends 9/11/05. Not scaled with load. All nodes are considered with equal weighting.



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NYISO Price Convergence
DAM and Real Time LBMP - NYCA Wide



For Discussion Only

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The convergence metric is a simple aggregation of hourly divergence on a nodal basis

Convergence Metric Formula

Backup

- The average absolute spread between the day-ahead and real-time market prices across all nodes was calculated using the following formula:

$$\frac{\sum_{\text{All Hours}} \left(\frac{\sum_{\text{All Nodes}} |\text{DayAheadPrice} - \text{RealTimePrice}|}{\text{Total Nodes}} \right)}{\text{Total Hours}}$$

- The average price was calculated across all nodes using the following formula:

$$\frac{\sum_{\text{All Hours}} \left(\frac{\sum_{\text{All Nodes}} \text{DayAheadPrice}}{\text{Total Nodes}} \right)}{\text{Total Hours}}$$