Impact of Virtual Transactions on New England's Energy Market

ISO New England Inc.
Market Monitoring Department
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I. Executive Summary

This Report details the effect of virtual transactions on the New England energy markets, with particular emphasis on convergence between the real-time and day-ahead prices. The Report is intended to address the questions posed by the Federal Energy Regulatory Commission ("the Commission") in its March 25, 2004 Order.[1] These questions are:

- What is the effect of virtual transactions on the energy markets it administers?
- Have virtual transactions led to price convergence between the real-time and day-ahead markets?
- Has virtual trading led to price discovery, liquidity, and trading options, without adding any appreciable costs?
- What other factors, if any, are potentially driving price convergence?

The Report period spans 18 months, from the beginning of Standard Market Design ("SMD") in New England in March 2003 until August 2004. The Commission's questions imply that virtual transactions should decrease the divergence between the real-time and day-ahead prices. Virtual transactions may also decrease the market price of risk, a potentially significant effect of virtual transactions on market efficiency. In order to determine the effect of virtual transactions on price convergence and on energy market efficiency during the Report period, both a statistical analysis of actual market activity and a market simulation model were used.

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[1] FERC Docket No. ER04-121-000, March 25, 2004, *Order Addressing Issues Raised at Technical Conference*, p. 11. Order is available at http://www.iso-ne.com/FERC/orders/ER04-121-000_3-25-04.pdf

The statistical analysis tested for effects of changes in virtual transactions activity on price convergence. The changes in virtual transaction activity were potentially driven by changes in the tariff used by the ISO to collect its administrative costs, which changed the costs of submitting virtual transactions. In theory, the tariff changes could be expected to influence virtual transactions in predictable ways. These predictions could then be used to check for changes in divergence coincident with changes in virtual transactions activity.

Statistical analysis suggests that the tariff changes reduced the number and MWh volumes of virtual transactions. There is some evidence that reductions in virtual trading activity coincided with an increase in day-ahead – real-time price divergence. Once the tariff charges were lowered on April 1, 2004, the degree of convergence was indistinguishable from levels during the period prior to the initial tariff charge introduction on January 1, 2004. The volatility of virtual transactions activity during the Report period suggests that there were other significant drivers of virtual trading activity. These results suggest that while virtual transactions may affect divergence, the current tariff levels are not high enough to have a detectable influence.

The New England benchmark model[2] was used to simulate the day-ahead prices that would be observed with and without virtual transactions. This modeling allows the direct computation of the impact of virtual transactions on convergence and market price

[2] The benchmark model has been used by the ISO for broadly determining the efficiency of New England's energy markets, as well as efficiency changes over time. This model has been applied in prior FERC Commission filings to estimate the effects of Demand Response program-induced load reductions on actual real-time energy prices. See, for example, ISO New England Inc., 2004, *Semi-Annual Status Report on Load Response Programs of ISO New England Inc.*, FERC Docket No. ER03-345-, June 30, 2004, p. 10-12. It was also used in prior ISO studies and reports. See, for example, ISO New England Inc., 2004, *Annual Markets Report 2003*. Document is available at http://www.iso-ne.com/smd/market_analysis_and_reports/public_forum_and_annual_report/2004_Annual_Forum/2003_Annual_Markets_Report_Final.pdf

of risk. Because the model is a simplified dispatch model, locational and other effects are not captured. Once the market acquired experience with SMD and divergence patterns became more stable, the presence of virtual transactions in the model led to increased convergence with simulated real-time prices. The results were ambiguous early in the period, in part because of virtual transactions activity associated with seller's choice contracts.

The computed market price of risk based on the benchmark model results, a more sophisticated measure of market efficiency than convergence, was lower with virtual transactions than without them, consistent with financial theory. The simulation model results suggest that virtual transactions both improve day-ahead – real-time price convergence and reduce the market price of risk.

The availability of virtual transactions has increased participation, and hence liquidity, in the New England electricity market, expanded trading options, and has not to date added appreciable identifiable costs to the implementation or operation of the New England market. Virtual transactions did not hamper the price discovery that is a feature of the ISO-administered energy market.

Many factors can potentially influence price divergence. Some of the factors are predictable, such as seasonality of load patterns or planned outages. Other factors are random, like unplanned transmission or generator outages, and differences between the forecasted and real-time load. These events may not be predicted in day-ahead market but may materialize in the real-time market. The impact of these events on divergence is unpredictable.

II. Introduction

This Report provides data on virtual transactions in the New England power markets and evaluates the impact of virtual transactions on the relationship between real-time and day-ahead electricity prices. The Report was developed in response to a requirement by the Commission that ISO New England ("the ISO") evaluate the effect of virtual transactions on New England's energy markets, including the extent to which virtual transactions contributed to price convergence between the day-ahead and real-time markets. Additionally, the Commission required the ISO to address whether virtual trading has led to price discovery, liquidity, and trading options, without adding any appreciable costs. Lastly, the Commission asked what other factors, if any, are potentially driving price convergence.

Virtual transactions have been a feature of New England's day-ahead electricity markets since the beginning of Standard Market Design ("SMD") in New England on March 1, 2003. They provide generators and load-serving entities with the flexibility to manage their financially binding day-ahead commitments at the hourly level. While supply offers and demand bids have a number of restrictions on the number of offers, trading locations, and the type of participant who can submit physical trades, virtual transactions have no such limitations.[3] They allow participants to optimally shape their supply offers and demand bids. Virtual transactions also allow entities other than generators and load-serving entities to participate in the day-ahead market. In theory,

[3] Supply offers and demand bids are limited to ten possible price-MWh volume pairs that are applied uniformly across all 24 hours. Supply offers must be associated with physical generation and can be submitted by a lead participant only. Demand bids must be associated with physical load and can be placed

virtual transactions improve multi-settlement market efficiency by allowing participants to arbitrage systematic differences between day-ahead and real-time prices. Virtual transactions also increase options and flexibility for managing physical production and delivery, in addition to permitting purely financial participation.

This Report seeks to address the Commission's question about the effect of virtual transactions on price convergence in two ways. One is based on a statistical evaluation of actual data; the other is based on a simulation of the market effects of virtual transactions.

First, the Report evaluates changes in virtual transaction activity. These findings are then used in an evaluation of convergence. Because changes in tariff rates have theoretically predictable effects on virtual transactions, virtual trading activity is tested for such effects. The next step is to determine whether identifiable changes in convergence patterns coincided with any changes in virtual transaction activity by developing an econometric model of tariff changes and convergence.

Second, the Report provides results from a market simulation model ("benchmark model") developed to evaluate the New England electricity market. This model uses actual offers and bids to calculate simulated prices in both day-ahead and real-time markets. The model is run with and without financial virtual transactions.[4]

The structure of the rest of the Report is as follows.

Section III of the Report provides background on virtual transactions that includes a discussion of the theoretical expectations of the effects of financial virtual transactions on prices and of tariff changes on virtual transactions.

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at the node by dispatchable and service station load only, and at the zonal level only by all other metered load.

Section IV provides a review of virtual transactions activity during the first 18 months of Standard Market Design ("SMD"), describing the changes in market participation, the number of submitted and cleared virtual transactions, and the volumes of submitted and cleared virtual transactions, and examines the impact of tariff changes on virtual transactions. Additionally, the Report evaluates the expected or identified changes in virtual transactions activity with the coincident tariff changes.

Section V provides data on the convergence between the day-ahead and real-time prices at the Hub and zones.

Section VI develops a statistical model to evaluate changes in convergence due to changes in tariff regime, and by inference changes in virtual transactions activity.

Section VII estimates the effect of financial virtual transactions on price convergence using simulation. The benchmark model directly estimates the impact of financial virtual transactions on day-ahead prices by comparing the modeled day-ahead prices to modeled counterfactual day-ahead prices excluding financial virtual transactions. Having estimated the day-ahead prices that exclude financial virtual transactions, the Report calculates the effect of these transactions on the market price of risk using simulated real-time prices.

Finally, the results of investigation that address the questions posed by the Commission are summarized in the Conclusions to the Report. The main conclusions state that virtual transactions have generally increased price convergence and lowered the market price of risk. Liquidity and trading options have also been improved and

[4] Financial virtual transactions are defined as those transactions exclusively placed to statistically arbitrage the difference between day-ahead and real-time prices, without any connection to physical generation or load.

expanded by virtual transaction activity, without to date imposing additional costs on the ISO.

III. Background On Virtual Transactions: Description, Theory, and Purpose

A. Description of the Instruments

Virtual transactions are financial instruments that were introduced concurrently with SMD in New England. They allow participants to buy or sell power in day-ahead market regardless of the control of physical resources. Virtual transactions are common in other multi-settlement electricity markets (e.g. NYISO, PJM). Through arbitrage, virtual transactions in theory ensure that the deviation between the day-ahead and real-time prices is consistent with an efficient market. Cleared virtual supply (increment or virtual offers, or "incs") in the day-ahead market at a particular location in a certain hour creates a financial obligation for the participant to buy back the bid quantity in the real-time market at that location in that hour. Cleared virtual demand (decrement or virtual bids, or "decs") in the day-ahead market creates a financial obligation to sell the bid quantity in the real-time market. The financial outcome for a particular participant is determined by the difference between the hourly day-ahead ("DA") and real-time ("RT") Locational Marginal Prices ("LMPs") at the location at which the offer or bid clears.

Incs and decs are analogous to the one-day short and long future positions for other traded commodities, such as gas and oil, with the day-ahead price being the settlement or strike price in financial futures markets. As financial instruments, virtual transactions have the following attributes:

- Incs and decs are submitted by 12:00 noon in the day-ahead market and represent virtual supply and virtual demand respectively. They are dispatched in the day-ahead market in the same way as offered generation and bid load.

- Incs and decs can be submitted at the Hub, zone, or node for which the ISO calculates an LMP.[5]

- In a given hour, the payoff from the cleared inc positions is (DA – RT)*Q and the payoff from the cleared dec is (RT – DA)*Q, where DA and RT are the day-ahead and real-time prices for that hour, and Q is the quantity cleared in the day-ahead market for that hour. The payoff can be positive or negative, depending on the value of the real-time price relative to the day-ahead price in each hour.

- Any market participant meeting the applicable credit balance or financial assurance criteria can submit incs and decs for any hour at any price up to $1000/MWh[6] and for a certain amount. Incs and decs are included in the supply and demand stacks at each location to determine the day-ahead LMP.

- Incs and decs provide generation owners and load serving entities more flexibility in shaping their day-ahead offers.

- Incs and decs are subject to the same Operating Reserve Charges ("ORC") on deviations as physical supply and demand bids. Incs are counted in the day-ahead supply position and are part of the deviation formula in the assessment of ORC.

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[5] Trading location may be a node, external node, load zone or the Hub as per *NEPOOL Market Rule 1.* Document is available at http://www.iso-ne.com/smd/market_rule_1_and_NEPOOL_manuals/NEPOOL_Manuals/M-35_Definitions_and_Abbreviations/M-35_Definitions%20And%20Abbreviations_%28Revision%208%29_09-10-04.doc.
The Hub is a set of 32 pre-defined nodes in Central Massachusetts and is a popular trading location in New England. See *NEPOOL Energy Market Hub White Paper and Proposal.* Document is available at at http://www.iso-ne.com/committees/hub_analysis_wg/2004_05_06/Meeting%20Materials/A2_NEPOOL%20Energy%20Market%20Hub%20White%20Paper%20and%20Proposal_04-08-04.doc

[6] Market Operations Manual 11, Section 2.5.2.(16): "Price-sensitive Demand Bids, Decrement Bids and External Transaction sales must be in compliance with the price cap level of $1,000 per MWh for Energy offer prices (such price cap level is as stated under Market Rule 1) and must be equal to or greater than

Incs are counted in the deviations calculation in real-time and are assessed real-time ORC. Decs are counted towards the day-ahead load obligation in the energy market and thus entail day-ahead ORC. Decs are also counted in the deviations calculation in real-time and are assessed real-time ORC.

B. Theory and Purpose of Virtual Transactions

Virtual transactions are an important part of SMD that allow participants greater flexibility in the day-ahead market and allow them to manage risk in a multi-settlement environment. They also facilitate statistical arbitrage when market participants believe they observe price divergences that lead to expected payoffs above the expected costs of placing virtual trades. In this process, virtual transactions may counteract market power that can lead to a different divergence value or pattern.

In energy markets, a certain risk premium may be warranted, and in power markets the day-ahead prices should not necessarily be unbiased predictors of the real-time price.[7] The modeling of systematic differences between forward and spot electricity prices[8] has been explored in prior research and tested using data in the PJM and

zero"; and (25): "Supply Offers, Increment Offers and External Transactions must be in compliance with the $1,000/MWh Energy offer price cap levels as stated under Market Rule 1."

[7] Ehud I. Ronn, 2003, Real Options: The Valuation of Flexibility in the Energy Sector, in Real Options and Energy Management (Risk Books, London); Sergey P. Kolos, and Ehud I. Ronn, 2004, "Estimating the Commodity Market Price of Risk for Energy Prices," Working Paper, Department of Finance, The University of Texas at Austin.

[8] Forward price is the price today for the electricity purchase or sale in the future. Examples of forward prices are day-ahead prices, futures prices on exchanges, or bilateral contract prices for future receipt/delivery. Spot prices are the real-time prices on the day of receipt/delivery.

California electricity futures markets.[9] This difference was also observed between the day-ahead and real-time hourly prices in a later analysis of the PJM market.[10]

In general, in a competitive market, any persistent premium placed on the price of selling or buying electricity (positive or negative) may reflect the relative value of locking in the day-ahead price to both producers and consumers. For example, if supply conditions are tight, producers may require and consumers may be willing to pay a day-ahead premium to avoid exposure to real-time price spikes due to unforeseen outages or higher than expected demand. Alternatively, if supply is robust, producers may want to lock-in a day-ahead price and thus be willing to transact at a discount to expected real-time prices.

Financial virtual transactions are presumed to exploit such premiums. If the real-time price is consistently below the day-ahead price, that would encourage the placement of financial incs so that participants sell in the expensive day-ahead market and buy back in the real-time market. Increased supply in day-ahead market would drive the day-ahead price down towards the realized real-time price, thus decreasing the price divergence. If the real-time price is consistently above the day-ahead price, that would attract financial decs. Increased demand in day-ahead market will drive the day-ahead price up towards the realized real-time price, thus again decreasing the divergence. This Report discusses whether financial virtual transactions made in the New England market to date led to the outcome predicted by theory.

[9] Hendrik Bessembinder, and Michael L. Lemon, 2002, Equilibrium Pricing and Optimal Hedging in Electricity Forward Markets, *The Journal of Finance*, 1347 – 1382.
[10] Francis A. Longstaff, and Ashley W. Wang, 2004, Electricity Forward Prices: A High-Frequency Empirical Analysis, *The Journal of Finance,* 1877 – 1900.

The expected premiums will differ, depending on the forecasted conditions of the system, as well as the uncertainty around this forecast. The realized premium will depend on actual real-time events. Because the expected premium is a function of the ex ante perceived real-time uncertainty, which varies with hour and day, the expected premium may vary by hour and day, too. So, while calculations of average differences between day-ahead and real-time prices are useful high-level metrics of market efficiency, combining hours with different hourly premia and uncertainties masks the complex role of risk premia in determining this divergence. This Report does not attempt to analyze risk premia at a detailed, hourly level, but rather looks at typical, daily risk premia for simplicity and tractability.

The market price of risk is another useful way of looking at market efficiency. The market price of risk not only looks at the expected reward for submitting a virtual transaction (negative for incs or positive for decs of the expected divergence) but also the risk associated with that reward. The market price of risk is the ratio of the expected relative change between the day-ahead and real-time prices to its volatility.[11] The market price of risk is a more appropriate measure of market efficiency, and thus of the impact of financial trading, than simple divergence since for any financial position the uncertainty of expected profits is as important as the expected profit itself. If the uncertainty varies over time, a measure, which ignores uncertainty, such as divergence, will ignore an important variable.

If virtual transactions were costless, financial traders would be expected to arbitrage away any persistent divergences between day-ahead and real-time prices. The remaining pattern of divergence would then be truly random, thus preventing any strategies involving incs and decs from extracting profits on average. At the same time, such changes would erase the premium that would objectively exist if only producers of energy offered and consumers of energy bid in the energy market. The market price of risk is expected to decline as financial players explore profitable opportunities. Changes in the market price of risk may indicate fundamental changes in market efficiency. Such changes might be the result of new entrants, learning by participants, and tariff charges or ORC affecting the costs of submitting or clearing virtual transactions.

However, virtual transactions are not free. Participants need to provide financial assurance that require capital or credit. There are also tariff charges, assessed per transaction, and ORC on cleared incs and decs that depend on cleared MWh. This Report focuses on the effect of tariff charges, because the imposition of these charges prompted the Commission's inquiry. Also, these tariff charges have varied in known, predictable ways during the Report period, unlike the other costs. This predictable variation may allow determination of charges in patterns of virtual transactions, and consequent changes in divergence and the market price of risk.

Since the beginning of SMD, virtual transactions have experienced three different tariff regimes. Prior to January 1, 2004, there was no tariff charge for either submitted or cleared incs and decs ("2003 Tariff"). Between January 1, 2004, and March 31, 2004, the charge was $0.584 per inc or dec for all submitted virtual as well as physical energy transactions ("2004A Tariff"). Beginning April 1, 2004, and pursuant to Commission order, a three-tiered rate design was introduced. It charges virtual traders $0.005 for all

[11] The reader will recognize the so-called Sharpe ratio for securities from CAPM and Arbitrage Pricing Theory. Since we are dealing with the forward positions, it is the expected rate of change rather than its

submitted incs and decs, then requires a second charge of $0.06 for all cleared virtual transactions ("2004B Tariff"). Physical transactions are assessed a single charge of $0.688 per supply offer or demand bid. All of the above charges are independent of bid MWh quantity, price, location or hour.

ORC depend on system conditions and physical dispatch. ORC on virtual transactions depend on the costs of out-of merit generation in day-ahead and real-time (Economic and RMR), as well as on deviations from dispatch that were caused by incs and decs. ORC can be Economic, spread pool-wide, and Reliability Must Run (RMR), assigned by load zone.[12] The average Economic ORC, and RMR ORC, charged in Connecticut and NEMA/Boston, are presented in Table 1.

Table 1 - Economic & RMR ORC Rate for Partial Years ($/MWh) [13]

YEAR[14]	ECONOMIC ORC RATE		ECONOMIC + CT RMR ORC RATE		ECONOMIC + NEMA RMR ORC RATE	
	INC	DEC	INC	DEC	INC	DEC
Mar – Dec 2003	0.61	0.64	5.85	5.94	4.20	4.39
Jan – Aug 2004	0.66	0.76	14.44	14.64	5.06	5.71

The ORC rate increased in 2004 as compared to 2003. RMR charges vary greatly by load zone, and are generally significant only in Connecticut and NEMA/Boston. Economic ORC are a fraction of RMR ORC in Connecticut and NEMA/Boston. The increase in RMR ORC is most dramatic in Connecticut in 2004.

The tariff and ORC should affect virtual transactions in a variety of ways. Based on the structure of these charges, this Report can make some preliminary predictions

premium over the risk free rate (as in the case of securities) that has to be divided by the volatility.

12 Note that other kinds of ORC (SCR, VAR) are not assigned to virtual transactions and are not discussed here.

13 Average ORC rates 2003 (March – December) and Average ORC rates 2004 (January – August). Inc = RT ORC average , dec = DA + RT ORC average. Dec rates are higher since they are charged day-ahead ORC.

regarding the response of submitted and cleared virtual transactions to the tariff changes and ORC.

- Higher tariff charges per submitted inc or dec may lead to fewer virtual transactions, as participants avoid submitting transactions least likely to clear.
- Higher tariff charges per submitted inc or dec may lead to more MWh per virtual transaction, as participants consolidate similar transactions.
- Higher ORC will decrease MWh cleared for a given expected level of divergence.

Because the tariff charges change in a known way at known dates, the expected effects listed above may be identified, and any effects on price convergence evaluated. While ORC charges are generally much larger than tariff charges, a systematic evaluation of their effect on virtual transactions, and resultant convergence effects, is difficult and not explored here. The Report does not explore those effects because ORC size does not vary predictably and because there are no clear changes in allocation or cost expectations during the Report period. So, while ORC applied to real-time deviations should clearly affect average divergence, the lack of systematic changes in ORC limits its use in this Report.

The Report seeks to determine the empirical effect, if any, of virtual transactions on the market. To do so, the Report evaluates several intermediate questions:

- Have tariff charges decreased the number of submitted virtual transactions, or increased the size of submitted virtual transactions?

[14] Here and in the rest of the Report year 2003 will refer to the period 1 March 2003 – 31 December 2003, and year 2004 will refer to 1 January 2004 – 31 August 2004, unless explicitly stated otherwise.

- Have these changes affected the day-ahead – real-time divergence or the market price of risk?
- Have virtual transactions increased or decreased divergence?
- Have tariff changes changed divergence patterns?

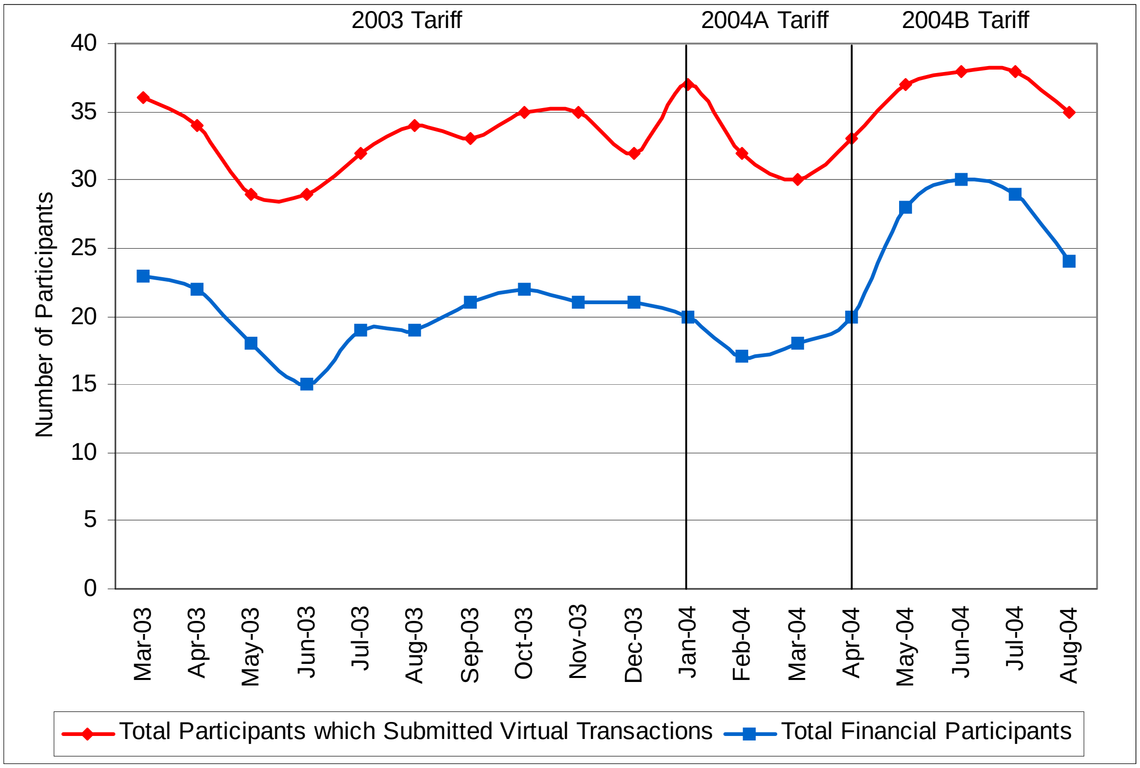
In general, the presence of virtual transactions and of financial traders in the market should decrease the market price of risk between the day-ahead and real-time prices.

IV. Virtual Transactions Activity since the Introduction of the Market

A. Participation in the Virtual Transactions Market

Figure 1 shows the total number of participants that submitted virtual transactions in each month. For comparison, it also shows the number of participants that primarily participate in the New England market through virtual transactions, *i.e*. those participants that do not own generation or serve load. The number of participants has been relatively stable since the beginning of SMD. No clear inference about the effect of tariff changes on participation in virtual transactions market can be drawn from Figure 1. In the peak participation month, July 2004, 38 participants actually submitted virtual offers and bids, out of 174 participants eligible to participate in the virtual transactions market. Participants that primarily engage in financial trading represent more than half of the total number. This indicates that virtual transactions have increased market participation.

Figure 1 – Number Of Participants In The Virtual Transactions Market



B. Number of Transactions

The total number of submitted and cleared incs and decs each month is shown in Figure 2. The dashed line shows cleared virtual offers and bids as a percentage of submitted transactions. Figure 2 shows a dramatic rise in the number of submitted virtual transactions from the beginning of SMD until November 2003, then a sharp drop in December 2003 and January 2004.[15] After January 2004 the number of submitted incs and decs leveled off. Table 2 shows that average numbers of transactions submitted before imposition of tariff charges are higher than averages after the changes.

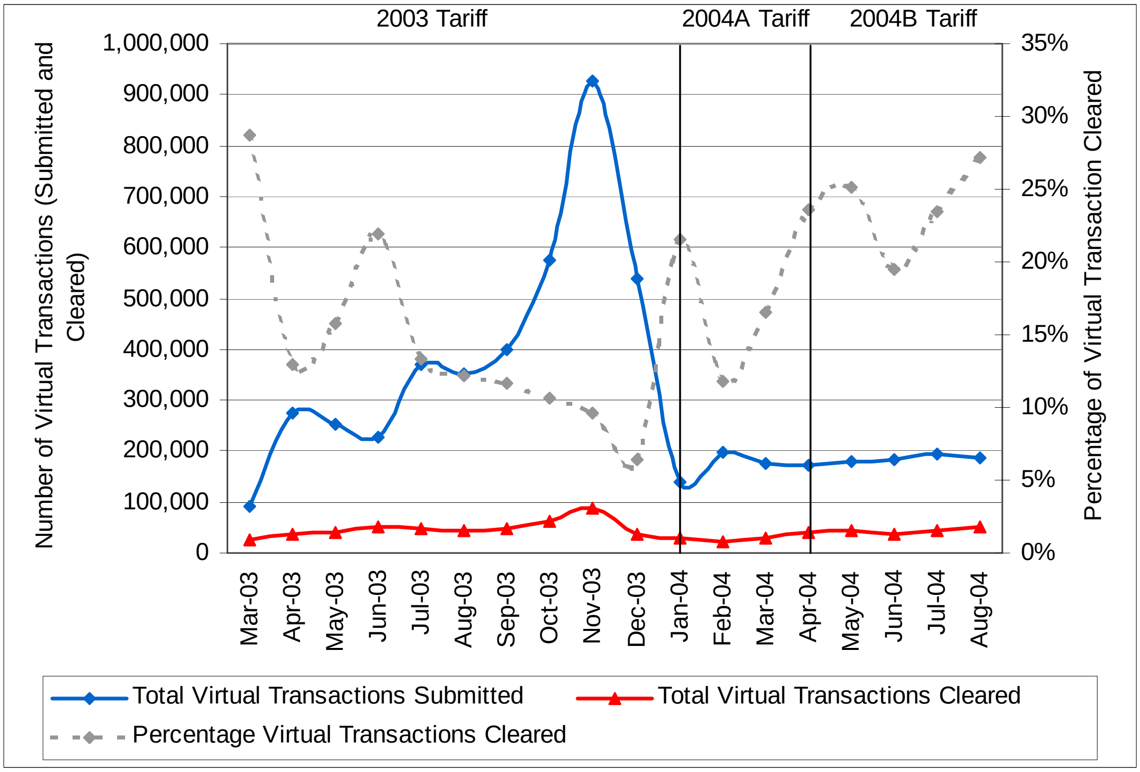
[15] This change is largely attributable to the actions of a small number of participants that changed their participation in the virtual transactions market.

Table 2 – Average Monthly Number Of Submitted And Cleared Virtual Transactions

Statistic	2003 Tariff	2004A Tariff	2004B Tariff
Submitted	400,393	170,899	182,451
Cleared	47,432	27,505	43,324
Cleared as % Of Submitted	11.9%	16.1%	23.8%

Cleared virtual transactions also experienced an increase through November 2003, falling by about 60% in December 2003. Starting in December 2003, the number of cleared virtual transactions oscillated between 20 and 50 thousand per month, with an upward trend. The trend in cleared transactions as percentage of submitted transactions shows a steady decline from June 2003 until January 2004 when it began moving upward, coincident with the introduction of the 2003 Tariff. This observation is consistent with expectations that tariff charges will reduce the number of virtual transactions generally, with the reductions coming primarily from virtual transactions least likely to clear.

Figure 2 – Total Number Of Virtual Transactions Submitted And Cleared



C. Volumes (MWh) of Virtual Transactions

The total MWh of submitted and cleared virtual transactions is presented in Figure 3. Prior to January 2004, the volume of submitted virtual offers and bids shows a very high monthly volatility, reaching a maximum in November 2003. After that, submitted volume dropped in December 2003 and then again in January 2004. The period after January 2004 was characterized by much lower volatility. The submitted volumes in 2004 are lower than in 2003 before the imposition of the 2004A Tariff. There is no clear change in trend or quantity between the 2004A and 2004B Tariff periods.

Figure 3 shows that cleared MWh are much less volatile than submitted MWh, and not well correlated with submitted virtual quantities. The cleared and submitted volumes in 2004 are lower on average than in 2003, consistent with tariff imposition. There is no clear change between the 2004A and 2004B Tariff periods.

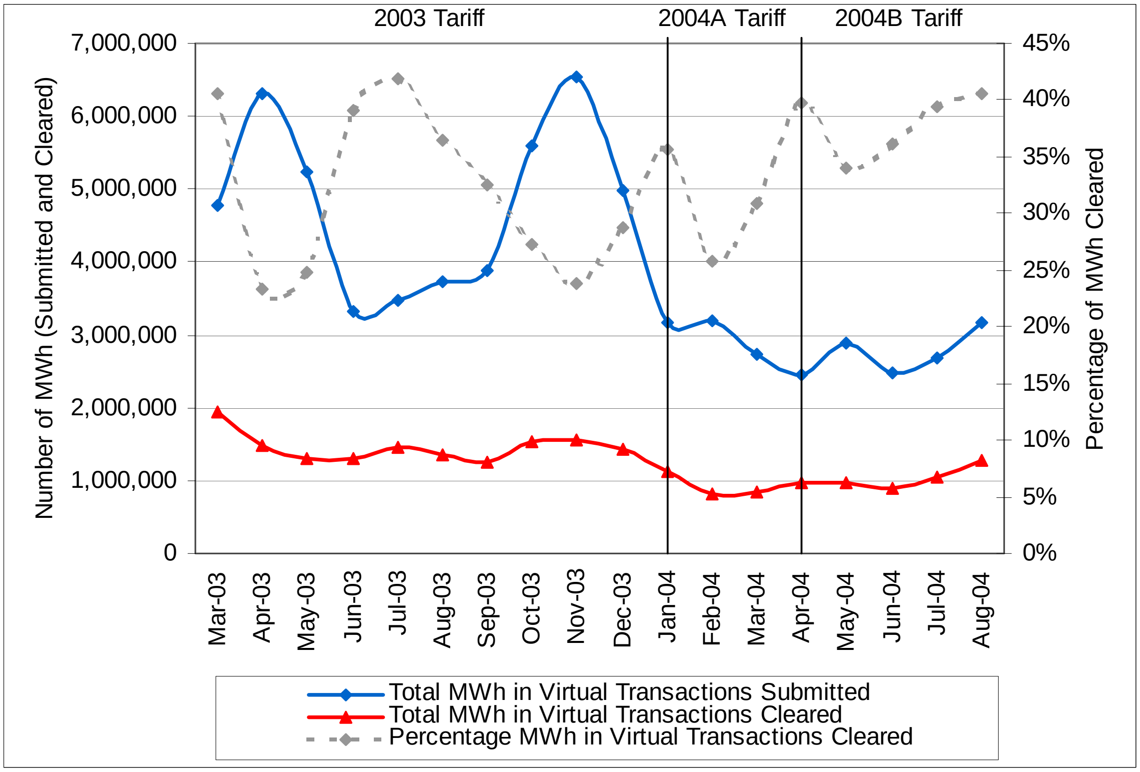
The percentage of cleared incs and decs does not exhibit a clear trend during the Report period. Volatility is high. The percentage cleared during the 2004B Tariff period is higher than during the 2004A Tariff period.

Table 3 - Average Monthly MWh Of Submitted And Cleared Virtual Transactions

Statistic	2003 Tariff	2004A Tariff	2004B Tariff
Submitted	4,787,131	3,031,576	2,737,359
Cleared	1,460,757	933,716	1,041,238
Cleared as % of Submitted	30.5%	30.8%	38.1%

The reduction of MWh submitted in 2004 is consistent with the expectations one would have regarding participants' reducing submitted transactions in response to imposition of Tariff charges. However, the reduction in MWh cleared is relatively modest, and there does appear to be an increase in the percentage of MWh cleared. This is consistent with expectations that those transactions least likely to clear would be most likely to be eliminated.

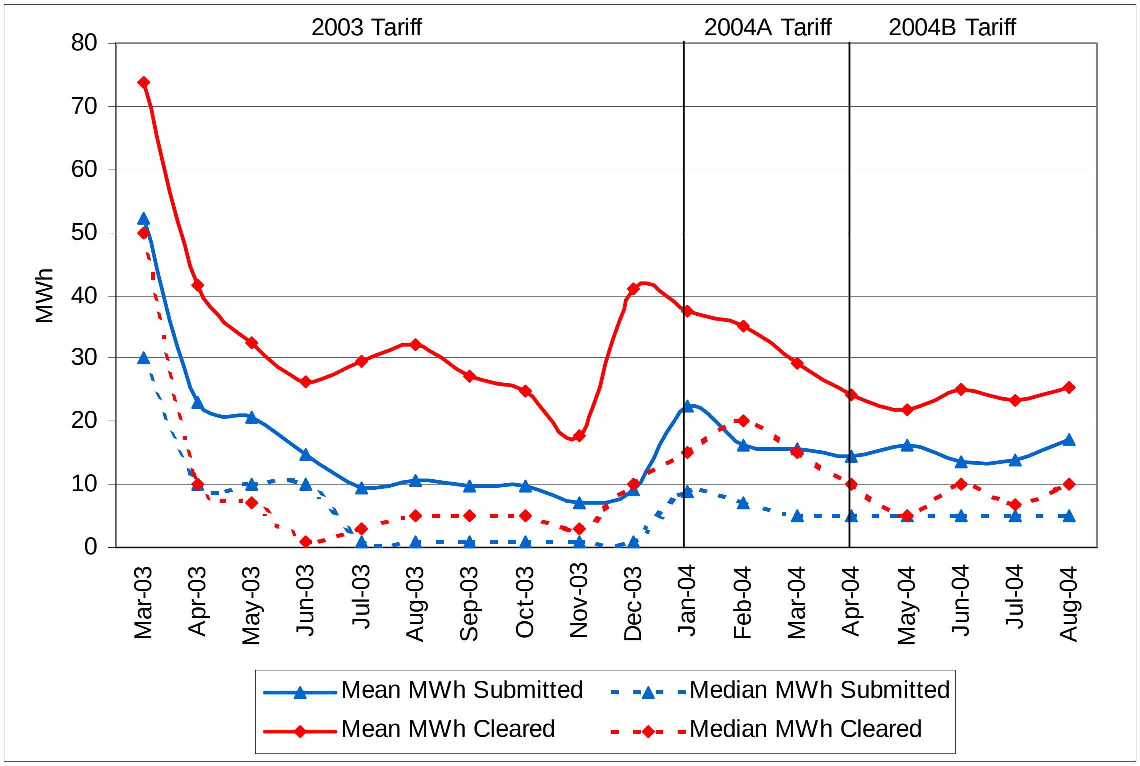
Figure 3 – Total Number of MWh Submitted and Cleared Virtual Transactions



Volumes per Transaction

Figure 4 shows both the mean and median MWh per submitted and cleared transaction.

Figure 4 – MWh Per Virtual Transaction Submitted And Cleared: Means And Medians



The mean submitted MWh per transaction increased with commencement of the 2004A Tariff, consistent with the expectations that participants would respond to per transaction charges by reducing small transactions and consolidating other transactions. The median of submitted virtual transactions suggests that from July through December 2003 there were many small volumes submitted. These small virtual transactions appear to be reduced by the introduction of the tariff in January 2004, consistent with consolidation or deletion of small transactions. The mean cleared MWh per transaction is always above the submitted mean MWh per transaction, suggesting that the fraction of small volume virtual transactions that did not clear was disproportionately large. The means and medians are well correlated, suggesting a relatively constant skew for both distributions.[16] It does not appear that mean cleared MWh per transaction was correlated with the tariff changes, though the median may have increased.

D. Statistical Analysis: Impact of Tariff Change on Cleared Virtual Transactions

As mentioned above, during the 2003 Tariff period the participation in the virtual transaction market was free, and coincident with the 2004B Tariff the cost was small but positive. In contrast, during the 2004A Tariff, the cost of participation in the virtual transactions market was relatively high. Consequently, due to the low cost of submitting virtual transactions, the Report would expect that the daily average number and the volume of cleared virtual transactions during the 2003 Tariff period and the 2004B Tariff regime to be greater than the daily average number and the volume of cleared virtual transactions during the 2004A Tariff, and the daily average number and volume to be greater during the 2003 Tariff period than under the 2004B Tariff.

In order to test this hypothesis, t-tests for the difference in the means of the average cleared MWh between all pairs of tariff regimes were performed.[17]

The results in Table 4 and Table 5 suggest that the daily number of submitted and cleared virtual transactions during the 2003 Tariff ("T0") was significantly greater than the daily number of cleared and submitted MWh during 2004A Tariff ("T1") and 2004B Tariff ("T2"). The number of submitted and cleared virtual transactions during the 2004B Tariff was greater than the number of submitted and cleared virtual transactions

[16] This intuitive skew should not be confused with the rigorous definition of the skew in Statistics.
[17] The null hypothesis is that the two means of cleared MWh across two tariff regimes are statistically equal. Rejecting the null hypothesis implies that the two means are statistically different.

during the 2004A Tariff; however, the difference between these two averages is not statistically significant.[18]

Table 4 - T-Tests for Submitted Daily Number of Submitted Virtual Transactions

Compared Tariffs	Compared Means		t-Statistic
2003 Tariff (T0) to 2004A Tariff (T1)	5,008 (T0)	3,550 (T1)	5.377 ***
2004A Tariff (T1) to 2004B Tariff (T2)	3,550 (T1)	3,404 (T2)	0.703
2004B Tariff (T2) to 2003 Tariff (T0)	3,404 (T2)	5,008 (T0)	-8.054 ***

*** Significant at 1 % level of significance

Table 5 – T-Tests for Cleared Daily Number of Cleared Virtual Transactions

Compared Tariffs	Compared Means		t-Statistic
2003 Tariff (T0) to 2004A Tariff (T1)	618 (T0)	358 (T1)	14.407***
2004A Tariff (T1) to 2004B Tariff (T2)	358 (T1)	560 (T2)	-0.722
2004B Tariff (T2) to 2003 Tariff (T0)	560 (T2)	618 (T0)	-17.291***

*** Significant at 1 % level of significance

The T-test for submitted and cleared MWh volumes of virtual transactions in Table 6 and Table 7 demonstrates the same observations for comparison of the 2003 Tariff period with the 2004A Tariff period, and for comparison of the 2004B Tariff period with 2003 Tariff period, as the observations for the number of submitted and cleared virtual transactions. In addition, the submitted daily volumes during the 2004A tariff period were significantly above the volumes during the 2004B Tariff period. This was not the case for cleared daily volumes.

Table 6 – T-Tests for Submitted Daily MWh Volumes Of Virtual Transactions

Compared Tariffs	Compared Means		t-Statistic
2003 Tariff (T0) to 2004A Tariff (T1)	54,870.25 (T0)	48,488.95 (T1)	3.257 ***
2004A Tariff (T1) to 2004B Tariff (T2)	48,488.95 (T1)	42,342.21 (T2)	3.140 ***
2004B Tariff (T2) to 2003 Tariff (T0)	42,342.21 (T2)	54,870.25 (T0)	-9.468 ***

*** Significant at 1 % level of significance

[18] A negative t-statistic for the difference T1 – T2 suggests that the average MWh cleared during tariff 1 was smaller than the average MWh cleared during tariff 2.

Table 7 – T-tests for Cleared Daily MWh Volumes of Virtual Transactions

Compared Tariffs	Compared Means		t-Statistic
2003 Tariff (T0) to 2004A Tariff (T1)	40,477 (T0)	23,992 (T1)	14.407 ***
2004A Tariff (T1) to 2004B Tariff (T2)	23,992 (T1)	24,766 (T2)	-0.722
2004B Tariff (T2) to 2003 Tariff (T0)	24,766 (T2)	40,477 (T0)	-17.291 ***

*** Significant at 1 % level of significance

The Report would also expect the daily average MWh size per transaction of submitted and cleared virtual transactions during the 2003 Tariff and the 2004B Tariff to be smaller than the daily average MWh size of submitted and cleared virtual transactions during the 2004A Tariff, and the daily average MWh size to be smaller during the 2003 Tariff than under the 2004B Tariff. Table 8 and Table 9 confirm the assumed relationship for MWh per transaction between the 2004A Tariff and the 2004B Tariff but do not confirm other assumptions.

Table 8 - T-Tests for MWh per Transaction for Submitted Virtual Transactions

Compared Tariffs	Compared Means		t-Statistic
2003 Tariff (T0) to 2004A Tariff (T1)	15.16 (T0)	15.90 (T1)	-0.641
2004A Tariff (T1) to 2004B Tariff (T2)	15.90 (T1)	12.88 (T2)	3.228 ***
2004B Tariff (T2) to 2003 Tariff (T0)	12.88 (T2)	15.16 (T0)	-2.727 ***

*** Significant at 1 % level of significance

Table 9 – T-Tests for MWh per Transaction for Cleared Virtual Transactions

Compared Tariffs	Compared Means		t-Statistic
2003 Tariff (T0) to 2004A Tariff (T1)	36.29 (T0)	35.30 (T1)	0.628
2004A Tariff (T1) to 2004B Tariff (T2)	35.30 (T1)	27.47 (T2)	6.665 ***
2004B Tariff (T2) to 2003 Tariff (T0)	27.47 (T2)	36.29 (T0)	-6.142 ***

*** Significant at 1 % level of significance

In summary, a large number and volume of virtual transactions submitted and cleared, characterized the 2003 Tariff. The introduction of a high tariff rate was coincident with the decrease in numbers and volumes of virtual transactions. The introduction of the 2004A Tariff coincided with the beginning of 2004, so some changes may be due to new participant strategies adopted for the new year. A subsequent reduction in the tariff rate led to a modest change in the number and volume of submitted and cleared virtual transactions from the 2004A Tariff period. These changes are often not statistically significant and may not be directionally consistent with expected changes, suggesting that other factors are influencing virtual transactions activity.

V. Overview of LMP Divergence in the New England Market

The difference between day-ahead and real-time prices in any given hour or day is the absolute divergence, defined simply as real-time price (RT) minus day-ahead price (DA).[19] Figure 5 presents the absolute divergence time series at the Hub. It also shows the three separate tariff periods described in the previous section: no tariff charge on virtual transactions from March 2003 through December 2003 (2003 Tariff period), from January 2004 through March 2004 (2004A Tariff period), and from April 2004 to the present (2004B Tariff period). Most of the time the prices in the day-ahead market are higher than in the real-time market, though divergence may be positive or negative on any given day. High divergence days are clearly identified by large spikes (positive or negative), such as during the January 2004 Cold Snap.[20]

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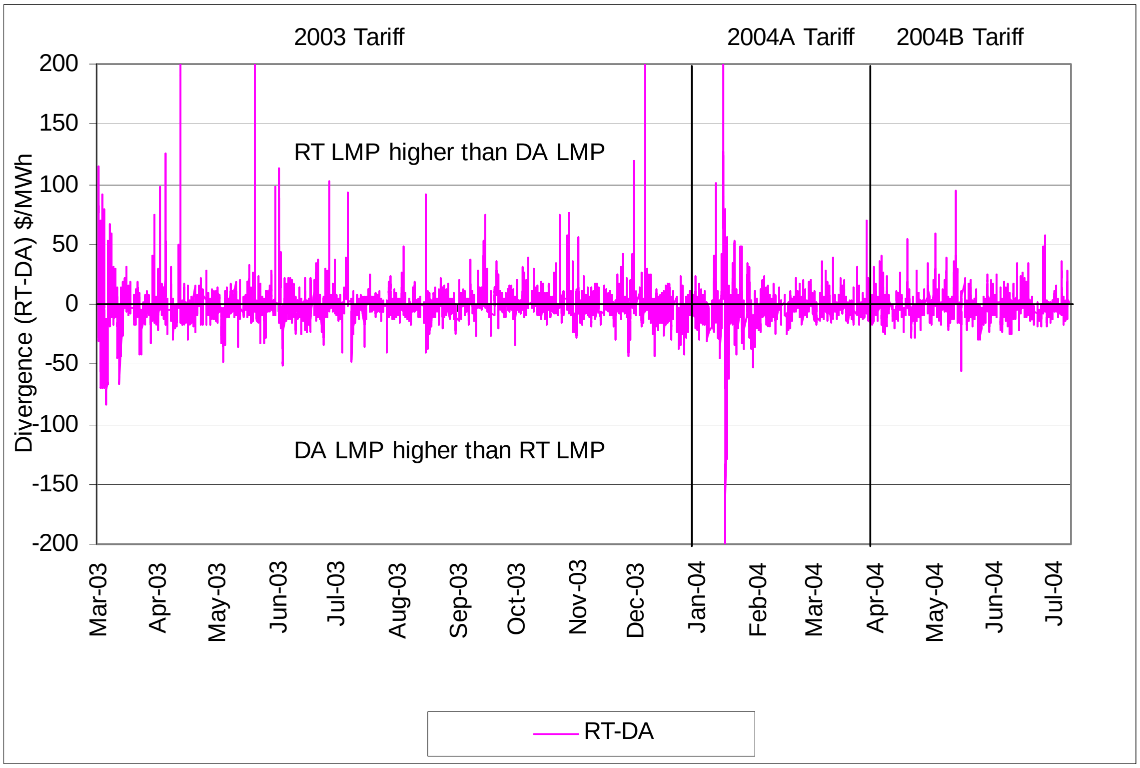
[19] In this report we follow the convention adopted in the ISO Annual Report, 2004, of defining the divergence as (RT – DA).

[20] ISO New England Inc., Market Monitoring Department, 2004, *Final Report on Electricity Supply Conditions in New England during the January 14 - 16, 2004 "Cold Snap"*. Document is available at http://www.iso-ne.com/special_studies/January_14_-_16_2004_Cold_Snap_Reports/1_Final_Report_On_January_2004_Cold_Snap.pdf

Figure 5 – Absolute hourly divergence (RT – DA) at the Hub[21]



The positive spikes are higher and more frequent than negative spikes, showing that unexpectedly high real-time prices occur more often than unexpectedly low real-time prices. This is because significant real-time events not forecasted in the day-ahead market are more likely to increase than decrease prices (e.g. generator or line outages nearly always increase prices).[22]

The deviation of relative divergence from normality is the proper measure for non-normality of financial time series. [23] The descriptive statistics of the density function of relative divergence in Table 10 confirm that spikes in real-time slant the distribution towards the right, fat tail, resulting in the positive skew and high kurtosis.

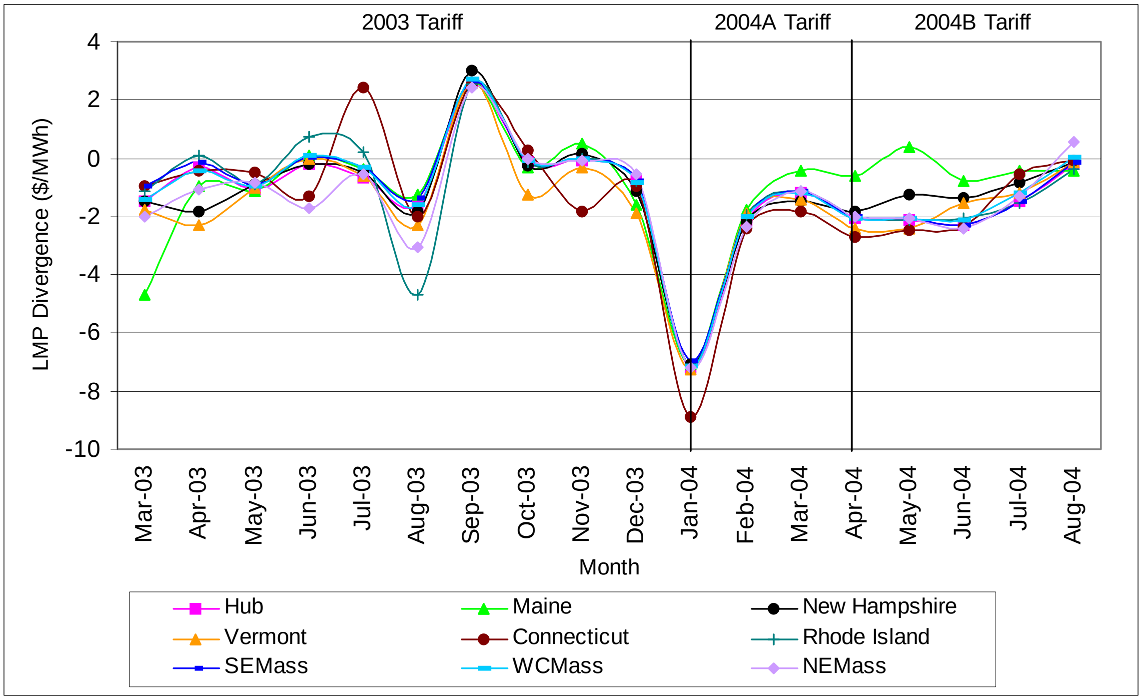
[21] The scale is limited to ± $200/MWh.
[22] Removal of 1 percent of highest and lowest absolute deviations (spikes) yields more symmetric distribution of deviations.
[23] The relative divergence is defined as the difference between the real-time price and day-ahead price, divided by the day-ahead price: (RT – DA)/DA or (RT/DA) - 1.

Table 10 – Statistics For Relative Divergence

Mean	Median	Std. Deviation	Skew	Kurtosis
-0.02	-0.03	0.27	13.07	586.63

The results for absolute monthly divergences at the Hub and zones are presented in Figure 6.

Figure 6 – Absolute monthly divergence (RT – DA) for the Hub and zones



Average divergence appears correlated for most zones in most months throughout the Report period. Those that appear to be outliers are zones that generally experience the most congestion (import or export constraints). In March 2003, LMP divergences in the Maine zone were significantly different from the rest of the Pool. This was caused by very active virtual demand bidding by participants with "seller's choice" contracts that settled in the day-ahead market, creating large amounts of day-ahead congestion in the

Maine load zone. Ultimately, many of these contracts were reworked.[24] The August 2003 outlier is Rhode Island, due to one day in which constraints modeled in day-ahead were handled differently in real-time.[25] Connecticut and Maine, an import and an export-constrained zone, respectively, account for the bulk of remaining outliers.

The unpredictability of binding constraints, and large potential price effects, can cause divergence for the small number of observations in a month. Extreme or unexpected weather can also lead to high divergences.[26] For example, cold weather in January 2004 led to the large fluctuations of day-ahead and real-time prices and on average a large negative premium.

Table 11 contains mean and standard deviation of divergence at the Hub for each Tariff and the overall values for the Report period. It shows that the 2003 Tariff period has average divergence smaller than the divergence during the 2004B Tariff period, which in turn was smaller than divergence during the 2004A Tariff period.

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[24] ISO New England Inc., 2004, *Annual Markets Report 2003*, p. 19 – 20. Document is available at http://www.iso-ne.com/smd/market_analysis_and_reports/public_forum_and_annual_report/2004_Annual_Forum/2003_Annual_Markets_Report_Final.pdf

[25] ISO New England Inc., 2003, *Monthly Market Report, August 2003*, p.7. Document is available at http://www.iso-ne.com/smd/market_analysis_and_reports/monthly_market_report/2003_Monthly_Market_Reports/2003_08_Monthly_Market_Report.pdf

[26] ISO New England Inc., Market Monitoring Department, 2004, *Final Report on Electricity Supply Conditions in New England During the January 14 - 16, 2004 "Cold Snap"*, p. 46 – 47. Document is available at http://www.iso-ne.com/special_studies/January_14_-_16_2004_Cold_Snap_Reports/1_Final_Report_On_January_2004_Cold_Snap.pdf

Table 11 – Mean and Standard Deviation of Real-Time – Day-Ahead Divergence at the Hub ($/MWh)

Tariff	Mean Divergence	Standard Deviation
2003 Tariff	-0.92	17.84
2004A Tariff	-3.47	33.12
2004B Tariff	-1.51	9.94
Overall	-1.51	19.67

VI. Econometric Analysis of LMP Divergence

Analysis in Section IV suggests that the imposition of tariff charges changed virtual trading activity. Finding that changes in the Tariff corresponded to changes in divergence would suggest that changes in virtual transactions activity influenced divergence patterns. To test this, the Report conducted an econometric analysis to test the effect of tariff changes on divergence, using the price divergence at the Hub as a proxy for system-wide price divergence. By investigating information for only the Hub the Report avoids problems associated with cross-sectional data.[27] The analysis is based on the Hub price data from the beginning of SMD through August 2004, including both on-peak and off-peak hours.[28]

The impact of tariff changes on LMP convergence is estimated using an econometric model similar to that of Saravia (2004).[29] The daily average divergence at the Hub is explained by changes in tariff regimes and time trend in Table 12. The time trend is used as an explanatory variable to account for change in the day-ahead and real-time LMP convergence as the market becomes more mature.

[27] Cross-sectional data is defined as a set of data values observed at a fixed point in time for various locations. The main problem associated with cross-sectional data is the heteroscedasticity, that is, that the error variance changes with respect to different values of the independent variable.

[28] Very high divergences from the 2003 Blackout (August 14th and 15th, 2003), December 5th, 2003 due to several OP4 hours, and the Cold Snap (January 14th, 15th, and 16th, 2004), are eliminated because of undue influence in a short data series, especially for the 2004A Tariff regime.

[29] C. Saravia (2004). Speculative Trading and Market Performance: The Effect of Arbitrageurs on Efficiency and Market Power in the New York Electricity Market, working paper, January 16, 2004 version.

Table 12 - List of the Independent Variables for the Econometric Model[30]

Independent Variable	Meaning of the Independent Variable
2003_*Tariff*	LMP data between March 1, 2003 – December 31, 2003
2004*A_Tariff*	LMP data between January 1, 2004 – March 31, 2004
2004*B_Tariff*	LMP data between April 1, 2004 – August 31, 2004

Other random factors, like unplanned transmission or generator outages, and differences between the forecasted and real-time load, also influence the price divergence. They are captured in the error term, u_i. The model specified above can be written as:

$$Divergence = \beta_1 2003\_Tariff + \beta_2 2004A\_Tariff + \beta_3 2004B\_Tariff + \beta_4 Trend + u_i .$$

The dependent variable, *Divergence*, is defined as the daily average difference between the day-ahead and real-time prices.[31] Therefore, a positive value for any of the tariff coefficients β_i means that, for the corresponding tariff regime, the day-ahead price is greater than the real-time price by the amount β_i. A negative sign on any of the tariff coefficients implies that the real-time prices are greater than the day-ahead prices. The null hypothesis is that the coefficients β_i should equal zero. Table 13 presents the results of the regression analysis.[32]

[30] The developed model has no intercept.
[31] In this section the Report temporarily adopts the definition of divergence as day-ahead minus real-time price.
[32] In order to correct for autocorrelation, an autoregressive model with 36 lags was estimated. The data has also been corrected for heteroscedasticity.

Table 13 - Results from the Regression Analysis

Variable	Coefficient Value (Standard Error)
2003_*Tariff* (03/01/2003 – 12/31/2003)	1.0940 (0.6769)
2004*A_Tariff* (01/01/2004 – 03/31/2004)	4.1769 *** (1.7068)
2004*B_Tariff* (04/01/2004 – present)	3.3990 (2.2290)
Trend	-0.0036 (0.0044)

*** Significant at 1 % significance level

The independent variables explain approximately 14% of the divergence. The rest of the divergence is due to other factors. This modest level of explanatory power is not surprising, as much of the divergence is expected to be driven by stochastic factors captured in the error term. The econometric results show that all coefficients of the tariff variables have a positive sign. The divergence between day-ahead and real-time prices during the 2004A Tariff regime was statistically significant. In other words, during 2004A Tariff, the Report expects day-ahead prices $4.18/MWh greater than the real-time prices, while during the 2003 Tariff, and during 2004B Tariff, the model cannot reject the hypothesis that the expected day-ahead price equals the real-time price.

The negative coefficient of the time trend implies that, as the market becomes more mature, the price divergence decreases. However, this coefficient is not statistically significant, even at the 10% level of significance.

During the 2004B Tariff period, divergence could not be distinguished from zero. The econometric analysis suggests that the 2004A Tariff period, through charges that decreased virtual transactions volumes, resulted in increased divergence. The model does not suggest such an effect during the 2004B Tariff period. These results must be interpreted with caution, as they are based on limited data and simple modeling efforts. The 2004A Tariff period is short, and therefore especially vulnerable to exogenous, short-lived factors that might affect divergence. One of the other significant factors that may potentially influence virtual transactions activity is Operating Reserve Charges ("ORC") on cleared virtual transactions. These results suggest that while the 2004A Tariff may have resulted in increased divergence, the 2004B Tariff period does not show increased divergence. Again, these results should be interpreted with caution due to the relatively simple modeling effort and short data series for the 2004A Tariff period.[33]

[33] Though the length of time-series by themselves is sufficient for the statistical analysis the Report conducts, other factors like outages may be coincident in duration with the relatively short 2004A Tariff period and thus be inseparable from the tariff effect in this analysis.

VII. Effects of Virtual Transactions on Divergence and Market Price of Risk

In this section, the Report compares modeled day-ahead prices to a modeled "counterfactual" day-ahead price reflecting the removal of purely financial virtual transactions in the New England energy market. Such a comparison directly addresses the effect of virtual transactions on price convergence. The Report removes only "financial" virtual transactions because the current market's physical offers and bids, together with incs and decs placed by participants to hedge physical positions, approximate the physical supply and demand positions that participants would seek to realize in the market if virtual trading was not available, assuming sufficiently flexible offers, bids, and bilateral contracts. That is, simply removing all incs and decs ignores the fact that participants would alter other offer and bid data to replace the hedging of physical positions eliminated with virtual transactions. Leaving "hedging" virtual transactions in the counterfactual market attempts to account for this expected adjustment.

A. Hedging and Financial Virtual Transactions

Virtual transactions are separated into hedging and financial categories, depending on the type of participant that submitted the virtual trade and where that virtual trade cleared. The following virtual transactions are deemed to be hedging:

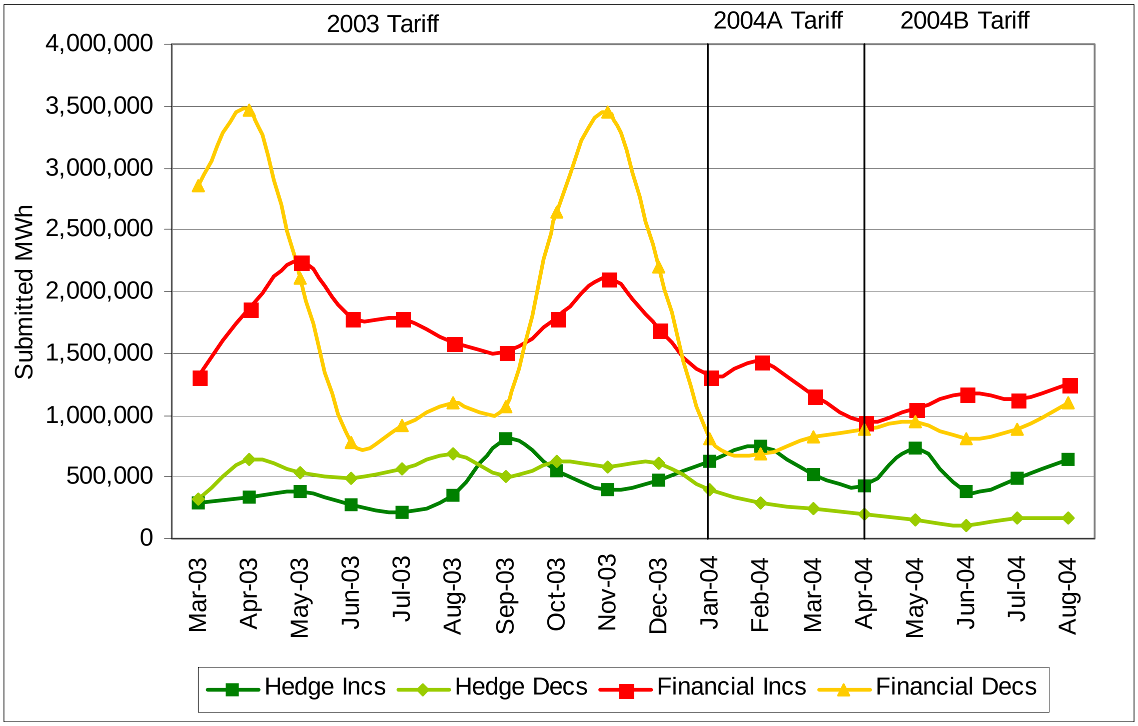
- If the participant that submitted the inc or dec is the lead participant of the generator where the virtual transaction was submitted.

- If the participant that submitted the inc or dec at a load node and has a real-time load obligation or an adjusted real-time load obligation at that node.
- If the participant that submitted the inc or dec at a load zone has a real-time load obligation or adjusted real-time load obligation at that zone.
- Some additional virtual transactions submitted by intermediaries (such as merchant energy companies and banks) at the load zones. These intermediaries place the virtual transactions for hedging as a service to some market participants.
- Some virtual transactions submitted at external nodes that are known to be hedging.

The remaining virtual trades at nodes or zones are considered to be financial virtual transactions.[34]

Figure 7 presents the total submitted MWh quantities of hedging and financial incs and decs. The imposition of the 2004A Tariff coincides with a decline in financial decs, and a smaller decline in financial incs. Most of the submitted volumes in Figure 3 come from financial virtual transactions. Hedging incs actually rose in volume at the implementation of the 2004A Tariff. Coupled with the decline in the number of bids, this implies an increase in the size of offers per transaction coincident with the introduction of the 2004Aariff, which is consistent with expectations. The introduction of the 2004B Tariff on April 1, 2004, does not seem to have an effect on submitted quantities.

Figure 7 – Submitted MWh Quantities of Hedging and Financial Virtual Transactions



The Report now uses this empirical information on financial virtual transactions to model their impact on divergence between day-ahead and real-time prices.

B. Benchmark Model Application

To assess the impact of financial virtual trades, the Report calculates prices for markets in which all cleared financial increment offers ("financial offers") and decrement bids ("financial bids") are included, and in which they are removed. The calculation uses a simulation model ("benchmark model"), in which an equilibrium price is derived from intersecting supply offers and demand bids[35]. The benchmark model calculates the

[34] Since the true intentions of participants placing virtual transactions are not always obvious or known, this classification, while attempting to create the adequate counterfactual market by utilizing the available evidence, may not be always accurately reflect the participant's strategy.

[35] Termed the "bid-intercept". See ISO New England Inc., 2004, *Annual Markets Report 2003*, p. 57-58. Document is available at http://www.iso-

equilibrium price under two scenarios: (a) Include all physical and virtual day-ahead supply and demand, including all financial and hedging incs and decs and (b) Include all physical supply offers and demand bids, and all hedging incs and decs. The modeled real-time price is computed using all available generation and load that materialized in the real-time market. The benchmark model has been used by the ISO for broadly determining the efficiency of New England's energy markets, as well as efficiency changes over time. These prices are compared with the simulated real-time prices. Deriving differences in price divergence with and without virtual transactions based on the benchmark model results produces a useful assessment of the effect of financial offers and bids on the divergence between real-time and day-ahead prices.

Figure 8 compares the divergence with and without financial virtual trades. On the left axis are divergences between the simulated day-ahead and real-time prices. The difference in divergences is due to the change in the benchmark day-ahead price once the financial virtual transactions are removed. On the right axis the graph shows a rescaled difference between the absolute values of divergence with financial virtual transactions and divergence without financial virtual transactions. In 2003 the presence of financial trades does not have a clear directional impact on the absolute value of divergence, though much of this is due to the short-lived problem with seller's choice contracts in Maine. This might be attributable to the market inexperience as well as an unstable pattern of divergence, shown in Figure 6. In 2004 the pattern of divergence became more stable. The model results suggest that financial transactions decreased divergence in all months of 2004 except for August, when the divergence was positive, but nearly zero.

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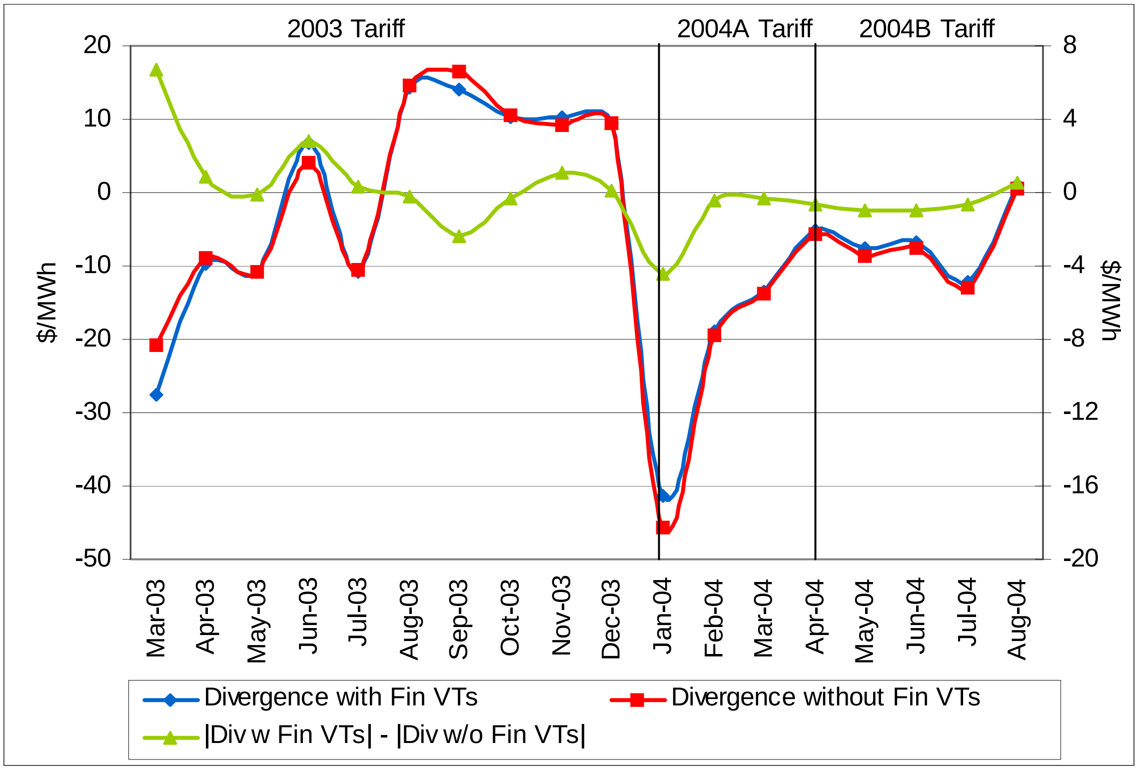
ne.com/smd/market_analysis_and_reports/public_forum_and_annual_report/2004_Annual_Forum/2003_Annual_Markets_Report_Final.pdf

These simulation results suggest that virtual transactions have driven the day-ahead price down towards the real-time price, thus decreasing the divergence.[36]

Figure 8 – Divergence with and without financial virtual transactions



In the next subsection the Report focuses on another measure of the market impact from financial virtual transactions – the market price of risk.

C. Financial Virtual Transactions and Market Price of Risk

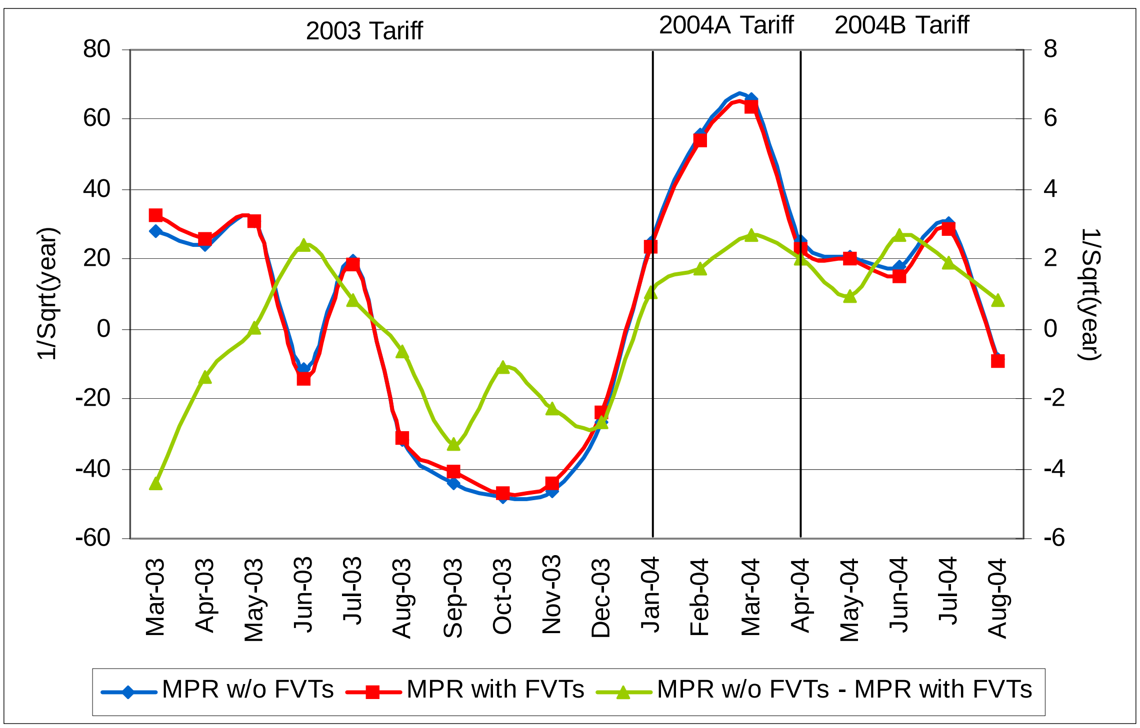
The Report mentioned before that a more sophisticated measure of efficiency and impact on the market is the market price of risk, with divergence being one of the inputs

[36] The divergences in Figure 8 reflect simulated day-ahead clearing prices, which may differ substantially from divergences based on actual real-time and day-ahead prices. The reader should bear in mind that the simulations reflect a purely economic dispatch of units to meet hourly loads. Unlike actual prices, these

into the computation. Comparing the market price of risk for the model results with virtual transactions and the "counterfactual" market without virtual transactions, based on the benchmark model results, produces a useful metric for assessing the effect of financial virtual transactions on the market.

Figure 9 plots on the left axis the market price of risk for daily average on-peak price (hour ending 8:00 to hour ending 23:00) with and without financial virtual transactions, as simulated by the benchmark model. Their difference is plotted on the larger scale on the right-hand axis.

Figure 9 – Daily On-Peak Market Price of Risk (MPR) with and without financial virtual transactions (FVTs) and their difference



These results are consistent with earlier findings about the influence of financial virtual transactions on divergence. As market participants acquire more experience, and

simulated prices reflect neither particular unit characteristics (e.g., minimum-run times), nor operational the patterns of divergence become more stable, the virtual traders exploit those divergences that present profitable expected payoffs, scaled by risks. As a result, the market price of risk decreased in 2004 due to their activity. As before, the message for 2003 is mixed. Overall, this suggests that financial virtual trades can successfully exploit divergences and their volatilities, given the cost of placing virtual transactions. Whether in doing so they successfully erase some market power, remove other market inefficiencies, or drive the market price of risk below the level that would be observed in a market of only producers and consumers of energy, remains an open question.

considerations such as re-dispatch requirements for local reliability, regulation, and voltage control.

VIII. Conclusions

This Report addressed the evolution of virtual trading and its potential impact on the market. Virtual trading attracted participants without physical generation or load obligations into the market and increased the number and volumes of submitted offers and bids. In this sense, the liquidity in the energy market increased.

The virtual trading features are an integral part of the SMD software that was adjusted to ISO specifications. It is impossible to separate costs of the virtual trading features from the rest of the SMD costs. However, if the volume of virtual transactions grows to an extent that requires an upgrade in hardware and/or new software, there could be incremental costs to the ISO. So far, such an upgrade has not been required. To date, virtual transactions have not hampered the ability of the SMD software to produce the day-ahead prices. In this sense virtual trading has not interfered with the price discovery that is a feature of the ISO-administered energy market.

Virtual transactions offer additional trading options to participants, as they are not bound by the limitations on physical trades. Participants extensively used virtual transactions for hedging physical transactions. Virtual trades also enabled financial market participants to engage in statistical arbitrage between day-ahead and real-time prices.

Many factors can potentially influence price divergence. Predictable factors include seasonality of load patterns or planned outages. Unpredictable or random factors include unplanned transmission or generator outages, and differences between the forecasted and real-time load. Random events may not be predicted in the day-ahead market but may materialize in the real-time market. The impact of the random events on divergence is also unpredictable.

The following are the main conclusions of the Report with regard to the imposition of tariff charges during the Report period:

- There is some evidence that tariff changes, which increased costs of virtual transactions, reduced virtual trading activity, especially in reducing submittals of transactions that were unlikely to clear. The volume of cleared transactions showed smaller changes in response to tariff changes, though the percentage of cleared MWh changed only slightly. The volatility of virtual transactions activity suggests that there were other strong influences on virtual transactions during the Report period.
- The change in divergence during the Report period does not seem to indicate a strong correlation with the tariff changes and hence with associated changes in virtual transactions activity. The econometric model suggests that only for 2004A Tariff was there an effect on the divergence pattern. This result should be viewed with caution, as the model is relatively simple, and the time period under 2004A Tariff was short. The results under the 2004B Tariff show no change in divergence.
- The results from the benchmark model suggest that once participants had had time to learn about the market and the pattern of divergence became stable, virtual transactions helped to decrease the divergence between real-time and day-ahead prices.

- Benchmark model results suggest that virtual transactions decreased the market price of risk. Once participants learned the price dynamics in the market and the divergence pattern became stable, financial virtual trades systematically decreased the market price of risk. Given the nature of financial virtual trades, this effect of virtual transactions on the energy market is consistent with expectations of financial theory.