Staff Analysis of

Uplift in RTO and ISO Markets

August 2014



Federal Energy Regulatory Commission

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I. Executive Summary

This paper is part of an effort to evaluate matters affecting price formation in the energy and ancillary services markets operated by Regional Transmission Operators (RTOs) and Independent System Operators (ISOs) subject to the jurisdiction of the Federal Energy Regulatory Commission (FERC or Commission). It covers the period 2009-2013 and focuses on the levels, trends, volatility and transparency of uplift costs. Data underlying this report were submitted confidentially to the Commission and have been aggregated to an appropriate level to mask the underlying data.[1]

As noted by the Commission in the public notice announcing the commencement of a proceeding to evaluate price formation issues, locational marginal prices for energy and ancillary services ideally would reflect the true marginal cost of production, taking into account all physical system constraints, and fully compensate all resources for the variable cost of providing service.[2] The RTOs and ISOs would not need to commit any additional resources beyond those resources scheduled economically; load would reduce consumption in response to price signals such that market prices would reflect the value of electricity consumption without the need to administratively curtail load.

In reality, however, RTO and ISO energy and ancillary services market outcomes are impacted by a number of technical and operational limitations.[3] Modeling, software and certain other limitations are, to some extent, inherent in the complexity of the electric system and the tools available today to maintain reliable operations.[4] For example, technical limitations in the market software prevent RTOs and ISOs from fully modeling all of the system's physical constraints. If physical constraints (e.g., voltage constraints) are not accurately reflected in the system model used to clear the market, the software outcome may not clear the resources needed to resolve all such constraints. In such a case, system operators may have to manually dispatch a resource that is needed to resolve a constraint (and manually re-dispatch other resources), with resulting energy and ancillary service prices not reflecting the marginal cost of production. RTOs and ISOs provide make-

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[1] Commission Staff appreciates the responsiveness of the RTOs and ISOs in addressing questions about uplift in their regions.

[2] *See Notice, Price Formation in Energy and Ancillary Services Markets Operated by Regional Transmission Organizations and Independent System Operators, Docket No. AD14-14-000 (June 19, 2014).*

[3] Although the discussion herein focuses on RTO and ISO markets, similar technical and operational limitations also impact the efficient commitment of resources by electric utilities operating in other market structures.

[4] Other efforts, like the annual market software conference, are intended to make progress on these longer term issues. *See* http://www.ferc.gov/industries/electric/indus-act/market-planning.asp.

whole payments, or uplift payments, to resources whose commitment and dispatch resulted in a shortfall between the resource's offer and the revenue earned through market clearing prices.

Nonetheless, understanding the reasons for uplift payments, the magnitude of uplift payments, and the impact on market participants and customers may help to shed light on markets, operations or infrastructure improvements to reduce the need for uplift payments. Preliminary findings indicate that:

- Uplift payments (i.e., credits) have been highly concentrated and recurring on a geographic or resource basis.
- Uplift payments are closely related to market fundamentals, including energy and fuel costs.
- Uplift payments are closely related to price divergences between day-ahead and real-time markets.
- The volatility of uplift costs varies across RTOs and ISOs and is trending upwards in three of the five markets studied.
- Uplift payments and the reasons they are incurred lack transparency.

This paper is intended to spur discussion and lead to a more comprehensive understanding of the drivers and market impacts of uplift costs. The conference scheduled for September 8, 2014, will provide one opportunity to learn the views of market participants, RTOs and ISOs, and market monitoring units (MMU).

Regardless of the underlying causes of uplift, a failure to make the causes transparent and to price them into the energy and ancillary services markets can undermine the effectiveness of price signals and efficient system utilization, and mute investment signals. Volatile uplift charges may also create financial uncertainty for customers, depress liquidity and reduce market efficiency.

II. Introduction

This paper explores historical trends and characteristics of uplift and the statistical relationship between uplift and certain market fundamentals in the wholesale markets of California Independent System Operator (CAISO), ISO New England, Inc. (ISO-NE), Midcontinent Independent System Operator (MISO), New York Independent System Operator (NYISO) and PJM Interconnection, LLC (PJM).[5] It is organized around three topics: uplift credits, uplift charges and data transparency. Throughout this paper the term "uplift credit" refers to a payment to a generator or other resource and "uplift charge" refers to an RTO's or ISO's recovery of uplift costs from market participants.

This paper does not attempt to assess whether uplift costs are too high or too low or whether specific uplift costs are warranted. Rather, the analysis presented here is intended to facilitate discussions concerning the matter of uplift as it affects price formation in the RTO and ISO energy and ancillary services markets. It is worth noting that costs giving rise to uplift payments, such as commitment costs, are not unique to RTO and ISO markets. These costs are inherent in reliably operating any electric transmission system.

Two sources of data were used. Data for the period 2009-2011 were obtained from each RTO and ISO in response to a FERC staff data request and includes: (1) daily uplift credits (uplift credits are calculated based on total revenues and costs for a given calendar day) and details on why individual uplift credits were made; (2) details on resources receiving uplift payments, including fuel and driver types (e.g., steam turbine or combustion turbine) and output capabilities; (3) bid information and marginal cost estimates during periods when uplift credits were made; and (4) details on uplift charges. Data for 2012 and 2013, where available, were obtained from RTO and ISO data submissions pursuant to Order No. 760.[6] Note that due to incomplete data not every analysis reported in this paper covers the complete period 2009-2013.

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[5] Southwest Power Pool is not included in this report because its day-ahead market was launched in 2014.

[6] *Enhancement of Electricity Market Surveillance and Analysis through Ongoing Electronic Delivery from Regional Transmission Organizations and Independent System Operators*, Order No. 760, FERC Stats. & Regs. ¶ 31,330 (2012). Paragraph 35 of Order No. 760 states the Commission may make publicly available staff white papers, among other things, that contain analyses derived from data that the Commission uses.

III. Uplift Credits

Uplift credits are payments made to resources whose commitment and dispatch by an RTO or ISO result in a shortfall between the resource's offer and the revenue earned through market clearing prices. While shortfalls can occur for many reasons, three primary reasons are: (1) a resource's operating costs and limits not being reflected in prices; (2) unmodeled system constraints; and (3) the dispatch and commitment of inflexible resources or the commitment of resources ineligible to set price. Each of these is explained further below.

RTOs and ISOs use a system of locational marginal pricing to establish clearing prices in the energy and ancillary services markets. At a very basic level, locational marginal pricing relies on the economic theory of variable, least-cost pricing. Under this theory, resources will offer their variable cost of production. Markets will clear in a least-cost manner based on operational practices and will send appropriate short-term price signals based on the marginal cost of production. Market clearing prices do not typically reflect certain components of a resource's actual operating costs (e.g., startup costs).[7] Because these costs are not reflected in market clearing prices, they must be recovered through infra-marginal revenue, which is the revenue a resource receives when the market clearing price exceeds its marginal cost. A resource may be able to fully recover start-up costs when it is primarily run as baseload, but may not recover start-up costs when operated for only a few hours each day.

Uplift credits may also arise due to an inability to fully model all of the system's physical constraints. If constraints, including voltage constraints, are not accurately reflected in the system model used to clear the market, the resulting market prices will not reflect the marginal cost of the resources needed to resolve constraints.[8] In such a case, system operators may have to manually commit and dispatch a resource that is needed to resolve a constraint (and manually re-dispatch or de-commit other resources). When these situations occur and the clearing locational marginal prices are insufficient to cover a resource's costs, RTOs and ISOs provide uplift credits to ensure that resources which followed the dispatch instructions are not harmed financially and thus remain willing to follow manual dispatch instructions.

Another potential cause of uplift is when an expensive resource is committed to be online to meet system requirements but some inherent inflexibility (e.g., minimum run

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[7] Start-up costs are generally the costs associated with bringing the boiler, turbine and generator from shut-down conditions to a state ready to synchronize to the system.

[8] The security constrained economic dispatch algorithms used by RTOs and ISOs are based on a direct current approximation of the transmission system and thus do not directly include voltage and stability constraints that exist in an alternating current system.

time) requires the resource to operate while it is uneconomic.[9] In this situation, the resource is precluded from setting the clearing price and the price is set by a less expensive (and marginal) resource that is backed down to make room for the inflexible resource commitment. For instance, a resource with a long minimum run time may need to be operated when it is uneconomic to do so. During many of those hours, the resource would receive less revenue than needed to cover its operating costs, so that an uplift payment is needed to compensate the resource for following the operator's dispatch signal. Additionally, resources that are committed for reliability purposes after the day-ahead market results are posted are typically operating at minimum output levels and not eligible to set price unless dispatched for energy and thus may operate at a loss. The commitment costs associated with such resources can be significant because of their operating characteristics.

Given the complexity of the electric system, it may be unrealistic to expect that uplift credits can be entirely eliminated from existing market designs. However, a system that takes into account physical system constraints and resource-specific operating requirements when determining the marginal cost of production would lessen the need for out-of-market actions that give rise to the need for uplift credits. That said, uplift credits reflect a component of the operating cost necessary to meet system needs and it is important to understand these costs and their role in the marketplace.

As noted above, the complexities of the electric system and the use of locational marginal pricing can give rise to the need to pay resources additional revenues (e.g., uplift credits) to keep them financially whole when they follow the directives of the RTO or ISO. To appreciate the significance of uplift that has been occurring in the RTO and ISO markets, the following sections highlight the preliminary observations about overall trends, concentration, and volatility of uplift credits and assess the relationship with other market fundamentals.

A. Trends

Uplift credits in absolute terms are large. Over the course of the five years examined (2009-2013), and across the RTOs and ISOs studied, they amounted to more than $5.5 billion dollars.[10] While large in absolute terms, uplift credits are relatively small when viewed in relation to load served.[11] As shown in Figure 1, uplift credits ranged between

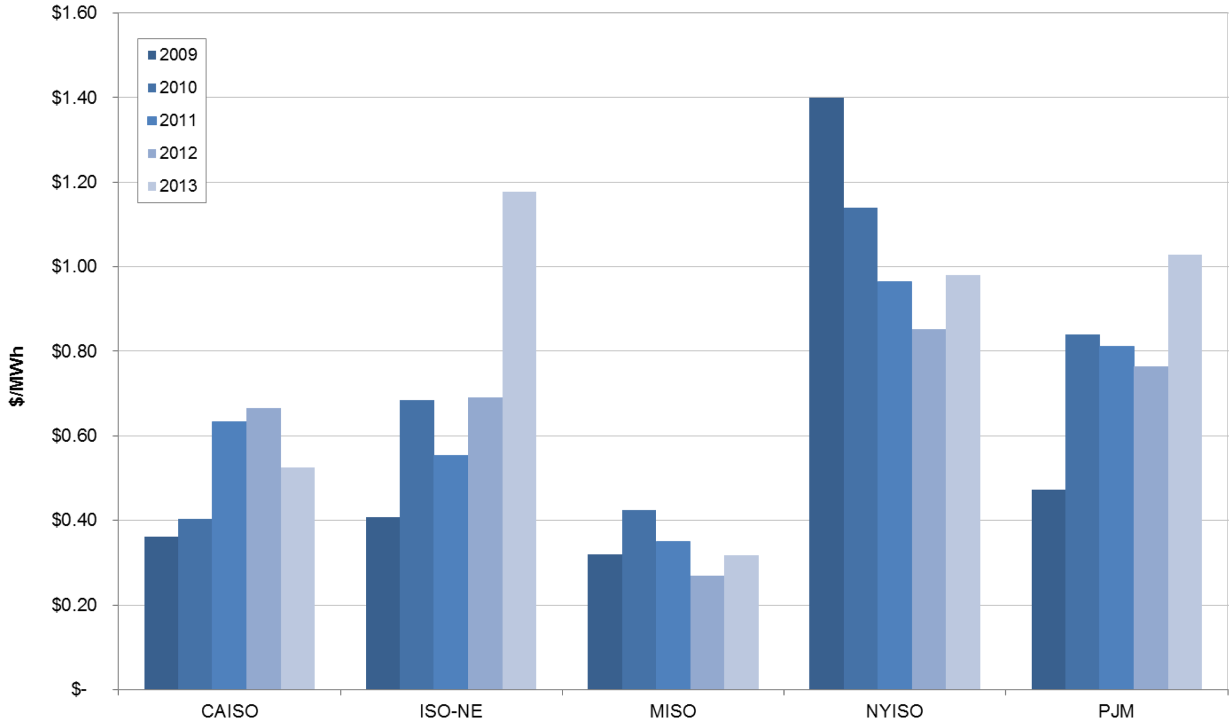
[9] The term "minimum run time" generally refers to the minimum number of hours of operation the generator requires the RTO or ISO to recognize when committing the generator.

[10] Appendix A contains annual uplift totals for each RTO and ISO. The size of total uplift credits may be influenced by alleged wrongful behavior that culminated in settlements with the Commission. *See e.g., In Re Make-Whole Payments and Related Bidding Strategies, 144 FERC ¶ 61,068, at P 85 (2013).*

[11] Annual average day-ahead locational marginal prices varied between $28/MWh and $57/MWh across the RTOs and ISOs.

approximately $0.30/MWh and $1.40/MWh, a fraction of the energy market prices during these periods.

Figure 1: Total Annual Uplift Credit by RTO and ISO ($/MWh)

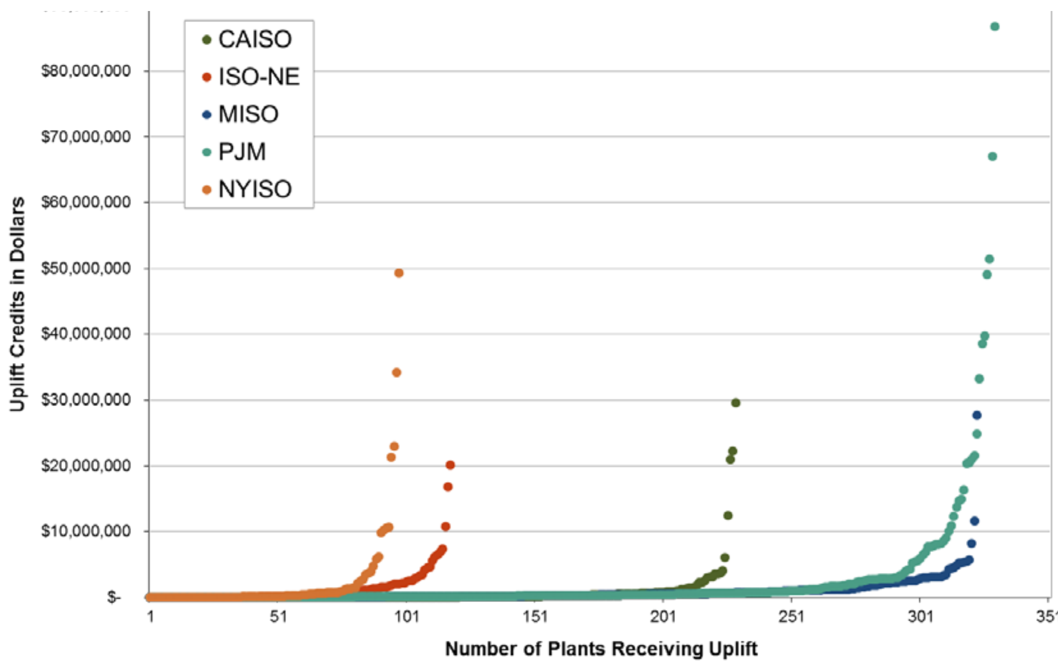


Note: Annual uplift ($/MWh) is calculated for each RTO and ISO as the total annual credits (in dollars) divided by the total annual hourly load (in MWhs). Total credits and total load for CAISO for 2009 are based on nine months of data beginning 4/1/2009. Total credits and total load for ISO-NE for 2012 has been estimated. Total credits and total load for PJM or 2012-2013 exclude those for reactive services (apr. $45 million/year).

B. Concentration

Uplift credits, or payments, appear to be highly concentrated within an RTO or ISO. To assess the degree to which they are concentrated, a review of the total uplift credits received by each plant reveals that most plants receiving uplift payments received small credit totals (under $1 million), while a handful of plants received substantially larger credit totals (varying between $5 million to over $80 million). Figure 2 displays annual uplift credit totals for individual plants during the most concentrated year, defined as the year when the greatest number of plants received uplift payments totaling more than $10 million. As can be seen in that Figure, four plants in CAISO, three in ISO-NE, two in MISO, 19 in PJM and seven in NYISO received more than $10 million in the selected years.[12] As a comparison, totals for plants receiving more than $5 million are as follows: five plants in CAISO, eight in ISO-NE, eight in MISO, 33 in PJM and ten in NYISO. Figures B.1 through B.5 in Appendix B show the yearly distributions.[13] These figures suggest that total uplift credits are not distributed evenly among resources.

Figure 2: Concentration of Uplift Payments by Plant During each RTO's or ISO's Most Concentrated Year



[12] For each RTO or ISO, the year selected was the year in which the highest percentage of total uplift payments were made to plants receiving at least $10 million. The analysis contained in Figure 2 and Figure 3 focuses on plants, which may represent multiple resources.

[13] Uplift payment totals have not been included for MISO in 2012 or 2013 and do not include reactive services related uplift for PJM. Totals for ISO-NE in 2012 only represent the third and fourth quarter.

Figure 3 shows the percent of uplift paid to plants receiving uplift credits in excess of $5 or $10 million for the most concentrated year. Market participants that received more than $5 million in uplift credits received over half of the total annual uplift credits in four of five RTOs or ISOs.

Figure 3: Percent of Annual Uplift Credits Paid to 'Large Recipients' Plants

	Year Studied	All >$5 Million Receivers	All >$10 Million Receivers
CAISO	2012	58%	54%
ISO-NE	2013	53%	32%
MISO	2010	29%	15%
PJM	2013	82%	70%
NYISO	2009	81%	71%

As noted previously, there are legitimate reasons why certain resources may receive large uplift credits. However, uplift credits made to the same resources year after year may indicate that market pricing is consistently failing to fully capture costs associated with committing and dispatching those resources or the existence of market work-arounds. For example, eight plants in NYISO each received more than $10 million per year over the course of 2009-2013. Of these eight plants, four received more than $10 million in every year studied. In PJM, one plant received uplift credits in excess of $60 million in each year studied, with the exception of 2012. As a point of comparison, plants under reliability must run agreements (RMR) can receive payments comparable to what a number of plants have received in uplift credits.[14] However, RMR agreements are typically for a defined period and are filed with the Commission for approval.

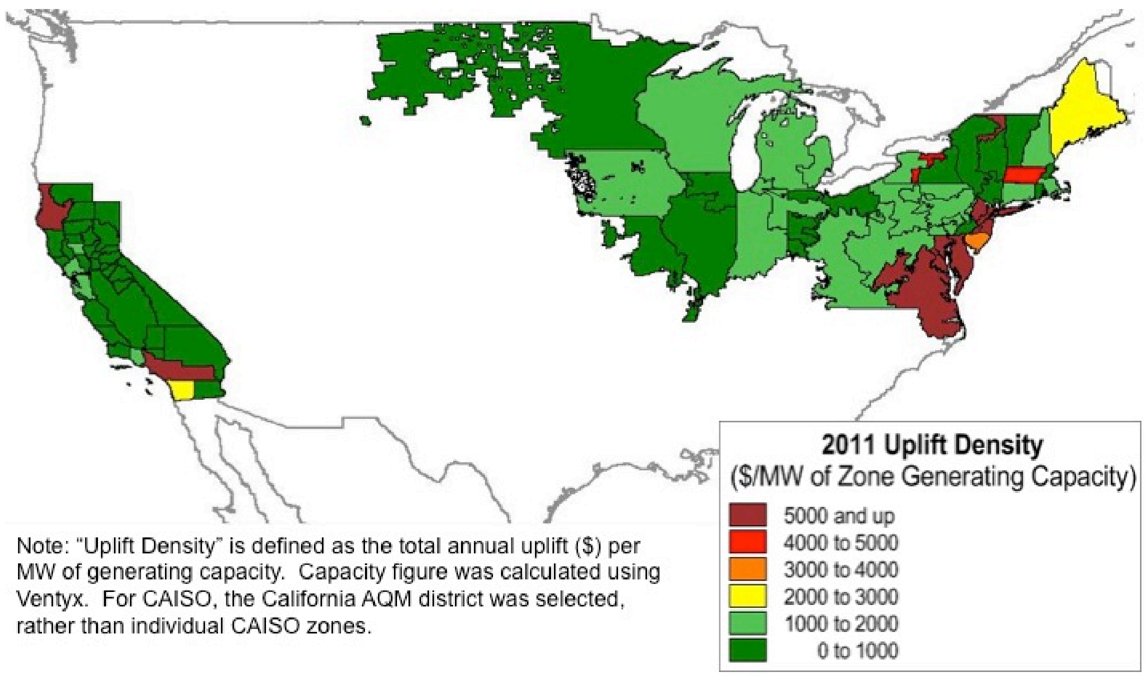
To better understand whether localized reliability concerns contribute to the concentration and persistence of uplift credits, a metric of average uplift credit for each MW of installed capacity was developed for each RTO and ISO zone. The resulting $/MW figures were then grouped into six levels and mapped to provide a visual representation of the relative intensity of average uplift credits received in a particular area.[15] This analysis was conducted for each year from 2009 through 2011. Figure 4, below, showing the

[14] Several recent RMR examples in PJM include 140 FERC ¶ 61,080 (Elrama and Niles (GenOn Power Midwest, LP)) and 135 FERC ¶ 61,190 (Cromby and Eddystone (Exelon Generation Company, LLC)). A recent example in MISO includes, *Midcontinent Indep. Sys. Operator, Inc.*, Docket Nos. ER14-109-000 & ER14-111-000, at 1-2 (Dec. 12, 2013) (delegated letter order) ((Gaylord (Consumers Electric Company)).

[15] California Air-Quality Management districts were used to give greater granularity to the data.

mapped 2011 uplift credits,[16] illustrates a few emerging patterns. Notably, uplift credits are consistently higher on a per MW basis in certain regions. These include the Dominion-Virginia and Delmarva zones of PJM and the NYISO zones in and around New York City. The NYISO North Zone (D) and Genesee Zone (B) had uplift credits of $5000 per MW and greater in both 2010 and 2011. Uplift credits per MW in Maine and Western Massachusetts have been higher than elsewhere in the ISO-NE region, although they fluctuated year-to-year. Among the RTOs and ISOs analyzed, MISO tends to have the lowest uplift credits per MW in all of its regions, although Wisconsin, Upper Michigan and Indiana showed some relatively high amounts in 2010. In CAISO, uplift credits per MW have tended to be relatively high in the South Coast Air Quality Management (AQM) district (the urban portions of Los Angeles, Riverside and San Bernardino counties as well as all of Orange County) and the North Coast Unified AQM district (Humboldt, Del Norte and Trinity counties in northern California). [17] San Diego also showed relatively high uplift credits per MW in 2011, though not as high as payments in the South Coast and North Coast Unified AQM districts.

Figure 4: 2011 Uplift Credits Mapped by Region



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[16] Maps showing the density of uplift credit totals geographically for each of the years 2009 through 2011 are included in Appendix C.

[17] Note that a small percentage of the total uplift data for 2009-2011 are not represented by these maps. The maps do not include any information from 2012-2013.

Even in areas with relatively low uplift costs, individual plants may receive large amounts of uplift payments. For instance, some units in the Wisconsin and Upper Peninsula of Michigan received substantial uplift payments to provide voltage support, despite the fact that this zone has relatively low uplift density.[18]

C. Correlation Between Uplift and Potential Market Drivers

This section explores the relationship between uplift credits and prices in three seemingly similar but distinct ways; correlations between uplift and: (1) relative fuel prices; (2) clearing prices; and (3) day-ahead and real-time price spreads.

1. Impact of Fuel Prices

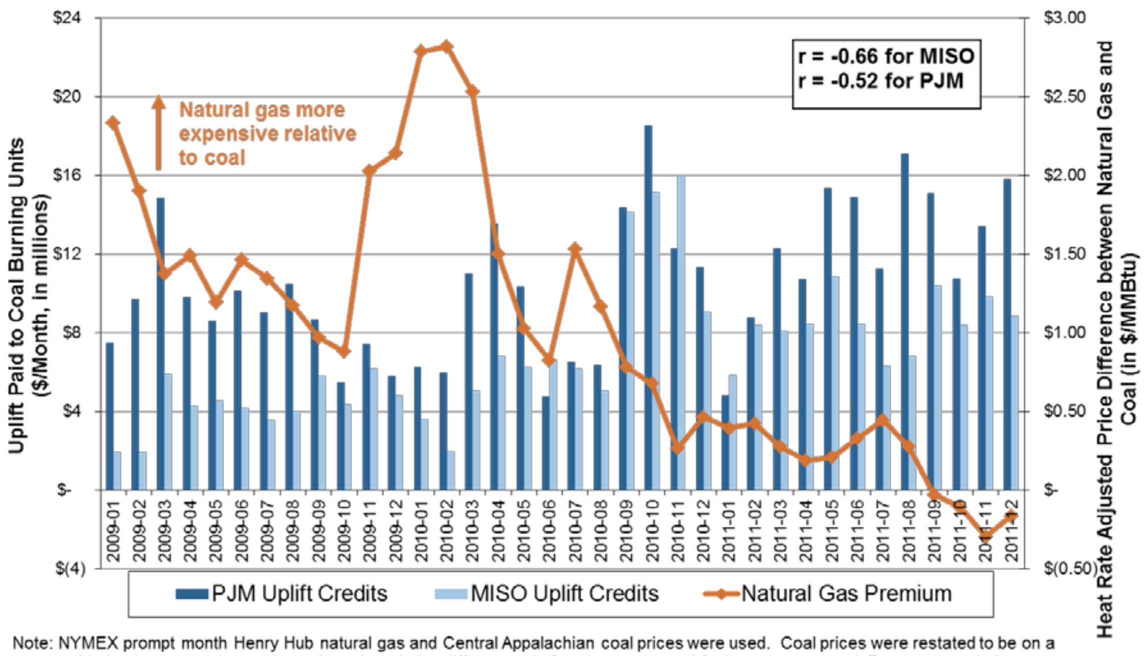
Changes in fuel prices can change the dispatch order of resources, which in turn will affect the opportunity for infra-marginal revenues. As the level of infra-marginal revenues changes so, too, does the need for uplift payments to compensate resources for costs not recovered through the clearing prices. For example, as the marginal cost of a coal resource approaches the cost of the cleared resource, the coal resource may earn less infra-marginal revenue that can be used to offset costs not included in its energy bid. In addition, some fuel-related costs (e.g., start-up costs) are not included in an energy bid, so any increase in fuel costs would tend to increase uplift credits. Further, resources that are needed for local reliability may not be dispatched when relative fuel prices change such that the resource is no longer economic. In such a circumstance, the resource may be committed for reliability and receive uplift credits to cover its operating costs.

To ascertain the relationship between the level of uplift credits and fuel prices, uplift credits paid to natural gas and coal resources in MISO and PJM were assessed. There appears to be clear trends in uplift credits to coal generation units associated with fuel prices. As shown in Figure 5, uplift credits paid to coal generation units have increased as natural gas prices relative to coal prices have decreased. In both MISO and PJM, the correlation between relative fuel prices and uplift credits to coal generation units has been fairly strong, -0.66 and -0.52, respectively. Additional charts showing this trend, including ones illustrating uplift to natural gas-fired plants, are included in Appendix D. Appendix D also includes information on uplift totals for the year 2011 by resource fuel type and prime mover. [19]

[18] *See* Midwest Independent Transmission System Operator, Transmittal Letter, Docket No. ER12-678-000, at 3 (filed December 22, 2011).

[19] Prime movers are devices that convert one energy form (such as heat from fuels or the motion of wind or water) into mechanical energy. Examples include steam turbines, combustion turbines, reciprocating engines, and water turbines.

Figure 5: Uplift Credits to Coal Burning Units in MISO and PJM



Note: NYMEX prompt month Henry Hub natural gas and Central Appalachian coal prices were used. Coal prices were restated to be on a comparable basis to natural gas prices given the relative differences in fleet heat rates and fuel energy output. A Pearson correlation coefficient (r) was used to assess for correlation between monthly fuel prices and uplift credits.

2. Correlation Between Uplift Credits and Clearing Prices

The relationship between uplift credit and market clearing prices is not clear-cut. Uplift credit may either increase or decrease as prices rise. Uplift credits and prices may be negatively correlated when, for example, clearing prices rise relative to bids of baseload resources, allowing the baseload resource to receive more infra-marginal revenue that can be used to offset costs not reflected in clearing prices. Further, to the extent the clearing prices are suppressed because of unit commitment decisions, the need for or level of uplift credits may increase. Conversely, uplift credits and clearing prices may be positively correlated to the extent both are influenced by fuel costs. Specifically, increases in fuel costs result in higher variable operating costs and higher start-up and no-load costs. Higher variable operating costs put upward pressure on prices.

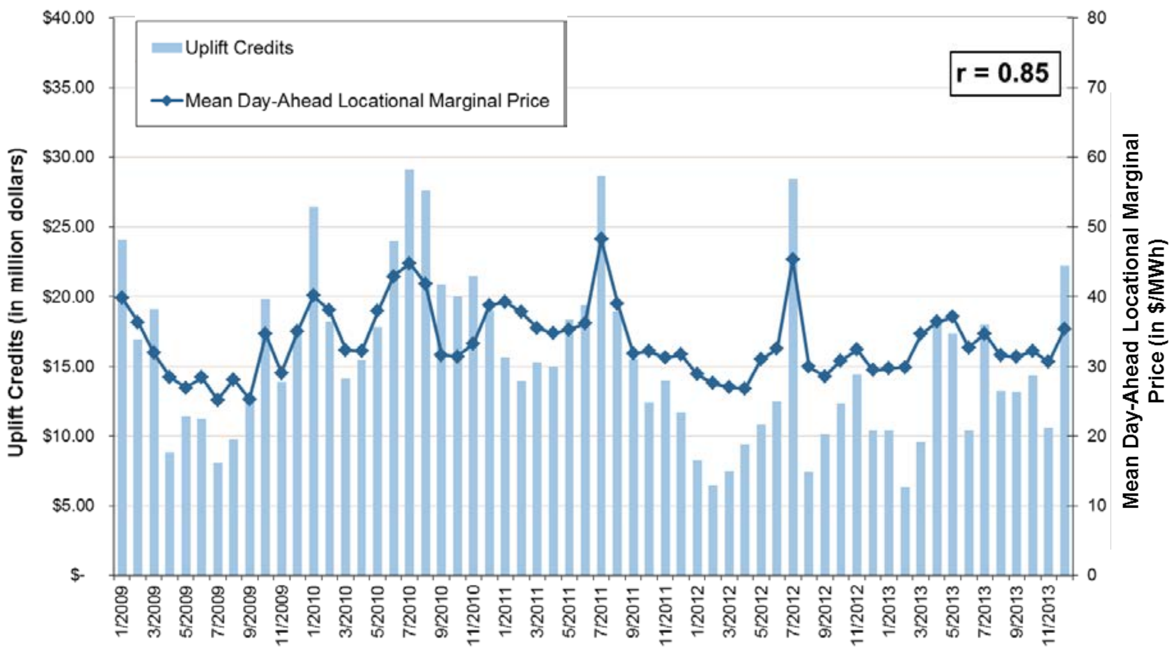
Total monthly uplift credits[20] and locational marginal prices were used to assess how uplift credit totals change with movements in day-ahead prices.[21] For nearly all the RTOs and ISOs, the data showed a strong, positive correlation between uplift credits and locational marginal prices. This suggests that uplift credits tend to rise with increases in

[20] Monthly uplift figures are the simple sum of daily uplift credits.

[21] Monthly figures were used to limit “noise” associated with daily volatility.

locational marginal prices. Figure 6 shows this trend for MISO - the strongest, positive correlation of any RTO or ISO studied. Appendix E contains figures for ISO-NE, NYISO and PJM (Figures E.1 through E.3). Although the figures show day-ahead locational marginal prices, the correlations between real-time locational marginal prices and uplift credits were very similar to the day-ahead correlations. In addition, there were clear seasonal patterns for both locational marginal prices and uplift, with both uplift and locational marginal prices peaking in the summer and winter and trailing off in the spring and fall. However, it is difficult to discern the relative impact of higher load levels versus higher fuel costs on uplift credits.

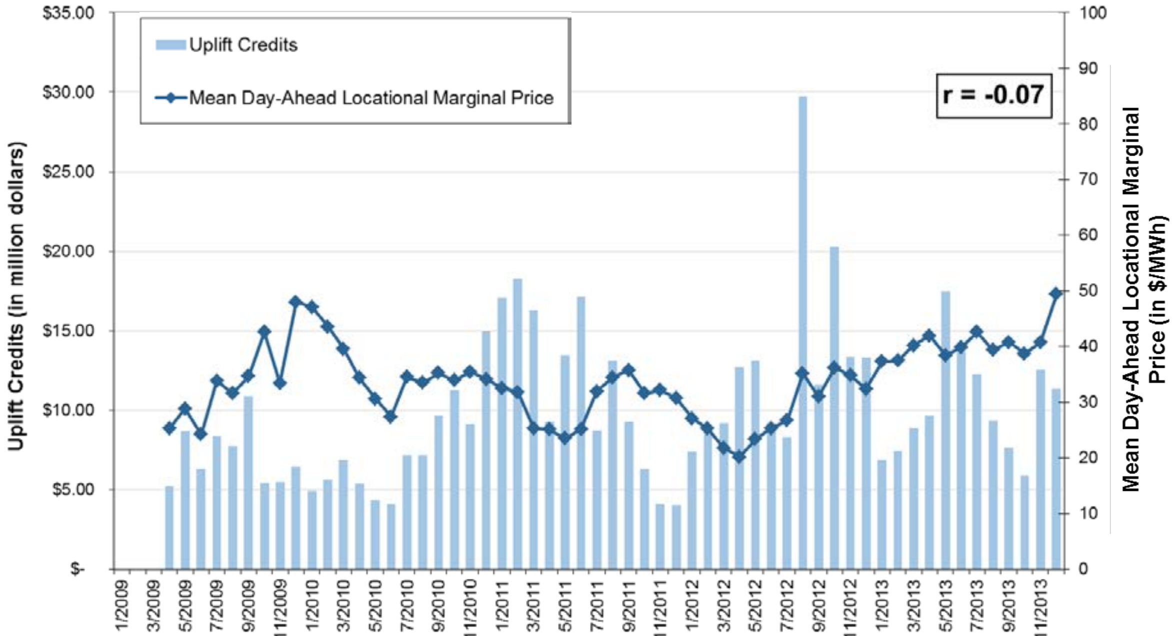
Figure 6: Uplift and Locational Marginal Price Correlation in MISO



Notes: The day-ahead locational marginal prices are CINERGY.HUB from Ventyx. The Pearson correlation coefficient (r) was used to assess correlation between monthly locational marginal price and monthly uplift credits.

For CAISO, as found in Figure 7, there was a slight negative correlation between day-ahead locational marginal prices and uplift. Interestingly, this negative correlation weakened with the addition of data from 2012 and 2013. This pattern is not consistent with the suggestion that fuel price changes are driving uplift costs in CAISO.

Figure 7: Uplift and Locational Marginal Price Correlation in CAISO



Notes: The day-ahead locational marginal prices are TH_SP15_GEN-APND from Ventyx. The Pearson correlation coefficient (r) was used to assess correlation between monthly locational marginal price and monthly uplift credits.

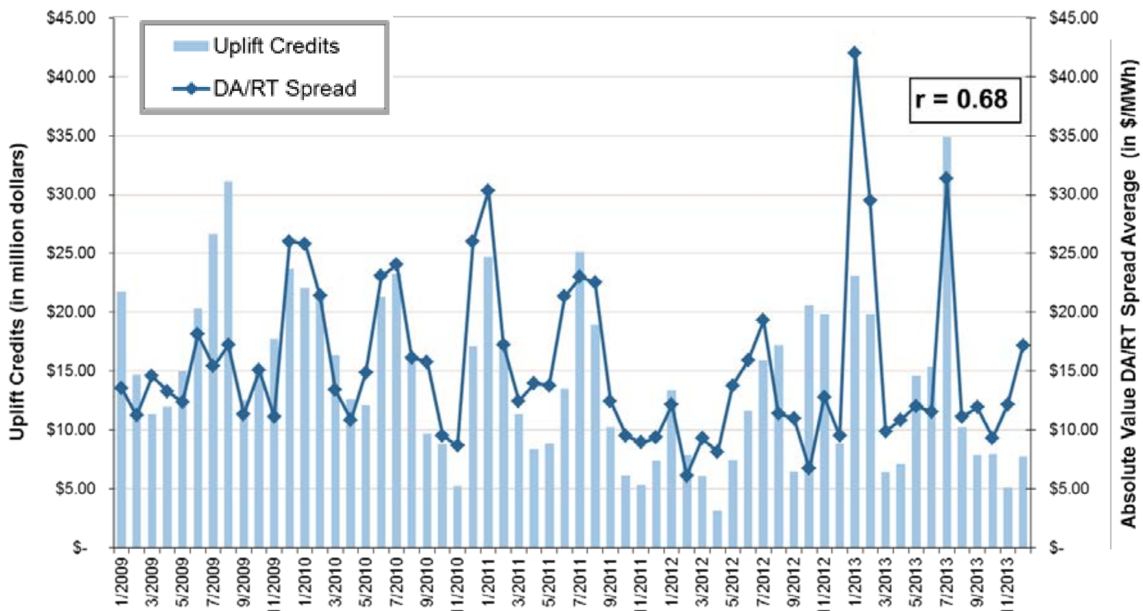
3. Impact of Day-Ahead and Real-Time Price Spreads

To further understand the relationship between uplift credits and prices, day-ahead and real-time price differences and uplift costs were assessed. Price spreads driven by high real-time prices relative to day-ahead prices may indicate that insufficient resources were committed day-ahead to reliably operate the system in real-time. Conversely, relatively low real-time prices could indicate that more resources were committed than were needed. The difference between the resources that clear in the day-ahead market or were committed prior to the real-time and the resources that are ultimately needed for real-time operations could influence uplift costs.

To ascertain the degree of any relationship between uplift credits and price spreads, the differences between day-ahead and real-time prices (hourly DA/RT spreads) at major price points in each RTO and ISO were identified. The absolute value of each DA/RT spread was used to calculate a monthly average of hourly DA/RT spread values. The values showed a clear correlation between price deviations and uplift payments. The correlation coefficient values for ISO-NE, MISO and NYISO were relatively strong at 0.85, 0.65 and 0.68, respectively. Analysis of PJM data also suggested a strong correlation, although less so at 0.47. Interestingly, these correlations weakened with the addition of 2012 and 2013 data. Similar to the above analysis on locational marginal prices, CAISO stood out in comparison to the other RTOs and ISOs and exhibited weak correlation between price deviations and uplift (0.23).[22] Results of this analysis are shown in Figures 8 and 9 for NYISO and PJM and in Appendix E for the other RTOs and ISOs (Figures E.4 through E.6).

The strong correlation between uplift credits and price spreads between the day-ahead and real-time markets suggests the accuracy of commitment decisions may strongly influence uplift and day-ahead and real-time price differences in RTO and ISO markets.

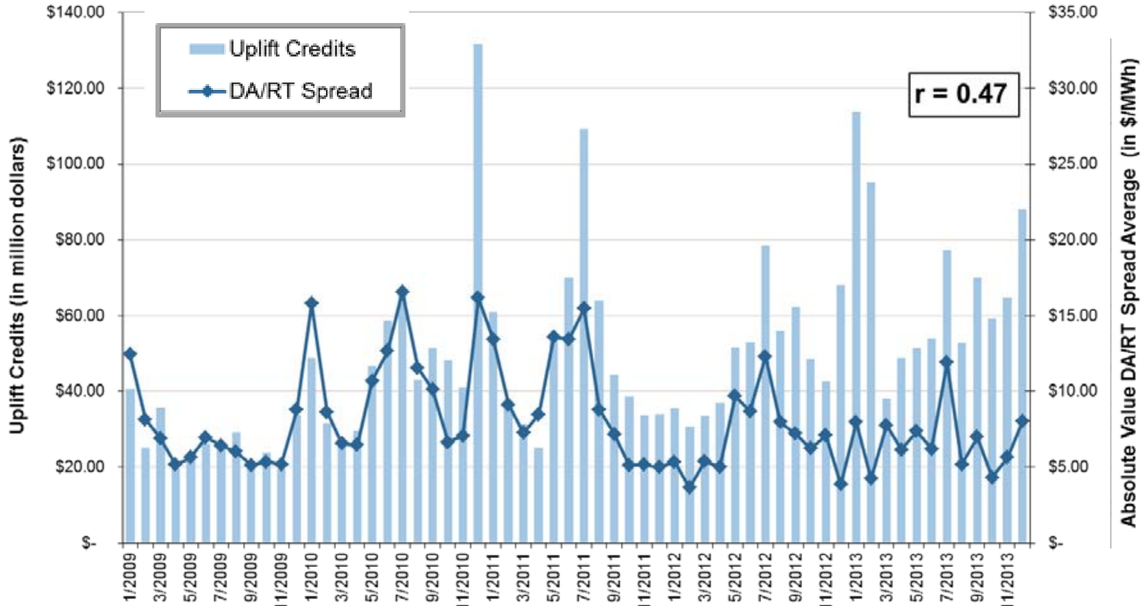
Figure 8: Uplift and DA/RT Price Spreads in NYISO



Notes: The day-ahead locational marginal prices are ZONE J from Ventyx. The DA/RT spread is the monthly average of the hourly, absolute value difference between the day-ahead and real-time locational marginal prices. The Pearson correlation coefficient (r) was used to assess correlation between monthly locational marginal price and monthly uplift credits.

[22] Unlike other RTOs and ISOs, CAISO operates an hour-ahead market in addition to operating day-ahead and real-time markets. The correlation between day-ahead/hour-ahead and hour-ahead/real-time prices did not show strong relationships between these price spreads and uplift credits.

Figure 9: Uplift and DA/RT Price Spreads in PJM



Notes: The day-ahead locational marginal prices are WESTERN HUB from Ventyx. The DA/RT spread is the monthly average of the hourly, absolute value difference between the day-ahead and real-time locational marginal prices. The Pearson correlation coefficient (r) was used to assess correlation between monthly locational marginal price and monthly uplift credits.

IV. Uplift Charges

While the preceding section focused on payments to resources (credits), this section focuses on uplift allocations (charges) to market participants. From the perspective of some market participants, unpredictable and highly volatile uplift charges tend to increase the risk of participating in the organized wholesale energy and ancillary services markets. If participants increase their bids to reflect increased risk or limit their participation in the market, this may result in increased market prices. This section presents an analysis of the volatility and uncertainty of uplift charges faced by market participants.

A. Daily Charge Volatility

To measure and compare daily uplift charge volatility in RTO and ISO markets, a coefficient of variation as a statistical indicator of volatility was employed. It shows the variation in values from the mean[23] and is a frequently used statistical indicator when measuring and comparing volatility of data sets with different means, which is the case for the uplift charges in RTOs and ISOs. In the following analysis, the coefficient of variation is expressed as a percentage.

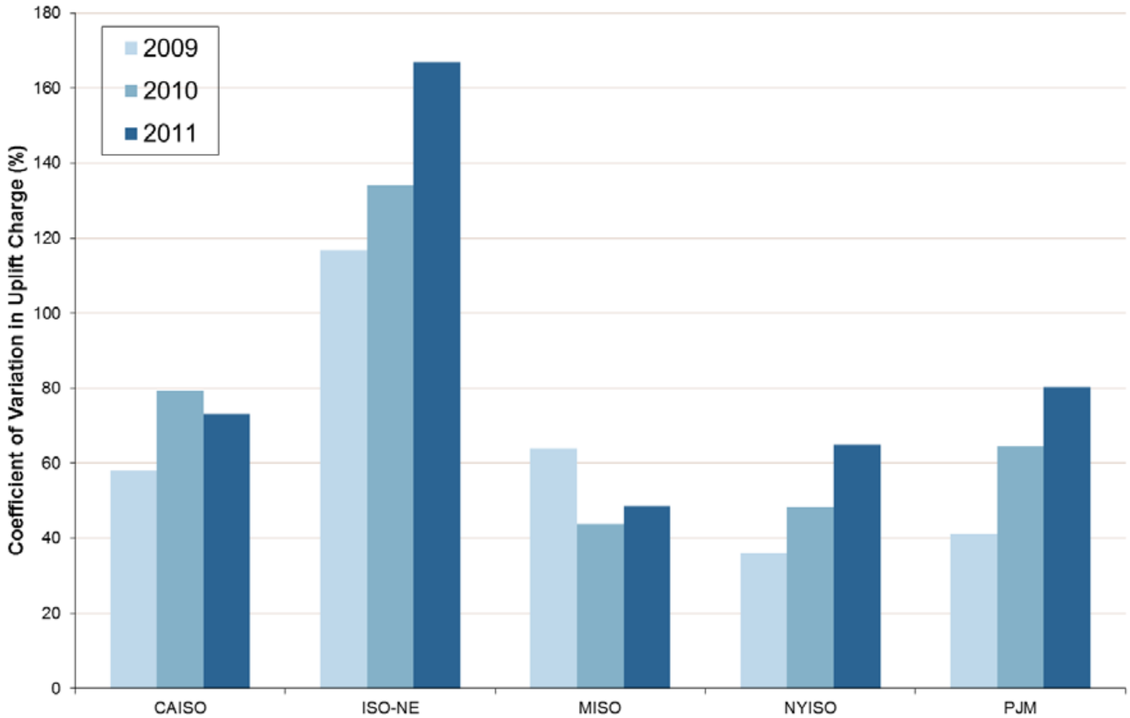
As shown in Figure 10, there was volatility in uplift charges on an annual basis and three of the five RTOs and ISOs experienced increasing uplift volatility during the study period. In 2009, the coefficient of variation in ISO-NE was approximately 117%, while the second highest was in MISO (64%), followed by CAISO (58%), PJM (41%) and NYISO (36%).[24] Annual uplift charge volatility in ISO-NE, PJM and NYISO increased in each year from 2009 through 2011. Notably, the volatility of uplift charges in ISO-NE increased to 167% in 2011 and, on average, was about 146% during the study period, exhibiting substantially higher volatility relative to other RTOs and ISOs throughout the three-year study period.[25]

[23] The coefficient of variation is simply the standard deviation divided (normalized) by the mean of the daily uplift charges over the annual measurement period. A low coefficient of variation indicates that the data points tend to be very close to the mean, whereas a high coefficient of variation indicates that the data points are spread over a larger range of values.

[24] During the three-year study period from 2009 through 2011, the average daily uplift charge per MWh was approximately $0.44/MWh in CAISO, $0.56/MWh in ISO-NE, $0.36/MWh in MISO, $1.13/MWh in NYISO and $0.66/MWh in PJM.

[25] The ISO-NE internal market monitor has noted liquidity reductions due to uplift charge volatility. *See* ISO-NE, *2013 Annual Markets Report*, May 1, 2014, at http://www.iso-ne.com/markets/mkt_anlys_rpts/annl_mkt_rpts/2013/2013_amr_final_050614.pdf, Page 6.

Figure 10: Annual Volatility of Uplift Charges by RTO/ISO



B. Frequency of Uplift Charge Rates

The previous section shows how total uplift charges for the entire market participant pool change on a daily basis. In order to better understand the impact of uplift charge volatility, the distribution of volatility across market participants was assessed. The uplift charges that an individual market participant is responsible for paying can vary significantly due to, for example, positions taken in the markets or unexpected events that may cause deviations (e.g., generator trips). Focusing on an uplift charge rate ($/MWh) instead of total uplift charges allows parallels to be more easily drawn across market participants with different market positions.[26]

Figures 11 through 13 depict the frequency of different uplift charge rate levels for day-ahead and real-time markets. In MISO during 2009-2013, day-ahead uplift charge rates were relatively consistent. MISO's day-ahead uplift charge rates averaged

[26] MISO and PJM are the only RTOs to publicly post the charge rates; charge rates for ISO-NE were calculated for the second half of 2012 and all of 2013. The day-ahead charge rate was calculated by dividing daily day-ahead uplift charge totals (in dollars) by total daily load obligation (in MWhs). Real-time rates were calculated by dividing daily real-time uplift charge totals (in dollars) by total daily deviations (in MWhs). Generation, load, virtual and import deviations were included in the real-time deviation calculation.

$0.04/MWh for the vast majority of days and were only above $0.25/MWh on two days. Day-ahead uplift charge rates averaged $0.16/MWh in ISO-NE and $0.12/MWh in PJM. In ISO-NE and PJM, 78% and 93% of days contained day-ahead uplift charge rates at or below $0.25/MWh.

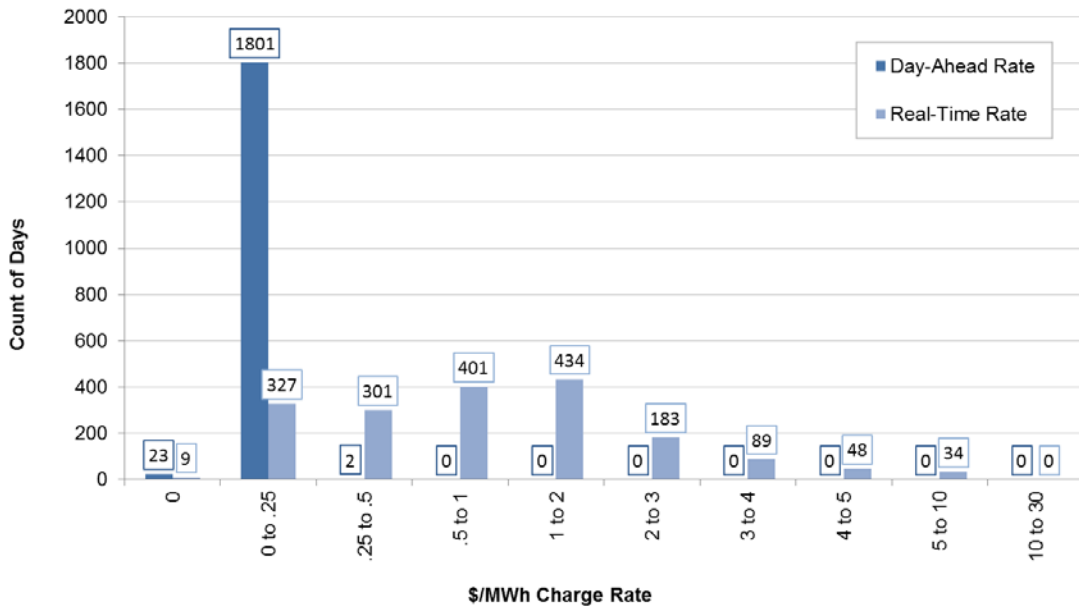
Real-time uplift charge rates, however, varied much more widely from day-to-day, occasionally reaching above $10/MWh. Daily uplift charge rates greater than $10/MWh never occurred in MISO. These high uplift charge rates were observed approximately 1% of the time in PJM and 7% of the time in ISO-NE. The simple averages of real-time uplift charge rates ($1.23/MWh in MISO, $2.38/MWh in ISO-NE and $1.57/MWh in PJM) were generally much higher than day-ahead uplift charge rates.[27]

Real-time uplift charge rates display greater variation than day-ahead uplift charge rates. The distribution of real-time uplift charge rates in MISO and PJM was concentrated in the $0.50/MWh to $1.00/MWh and $1.00/MWh to $2.00/MWh ranges. In MISO and PJM, these two ranges accounted for about 46% and 63% of observed uplift charge rates, respectively. The number of uplift charge rates observed at higher price levels generally dropped progressively in MISO and PJM. Conversely, the ISO-NE real-time uplift charge rate distribution has greater frequency at both low and high rates, suggesting that market participants are more frequently exposed to either relatively low or relatively high rates.

These data show that in real-time a market participant in MISO, ISO-NE and PJM faces uncertain and volatile uplift charge rates. As a result, market participants may build risk premiums into any resource bids placed into real-time energy markets to shield them from the risk and uncertainty associated with unexpected uplift charge rates.

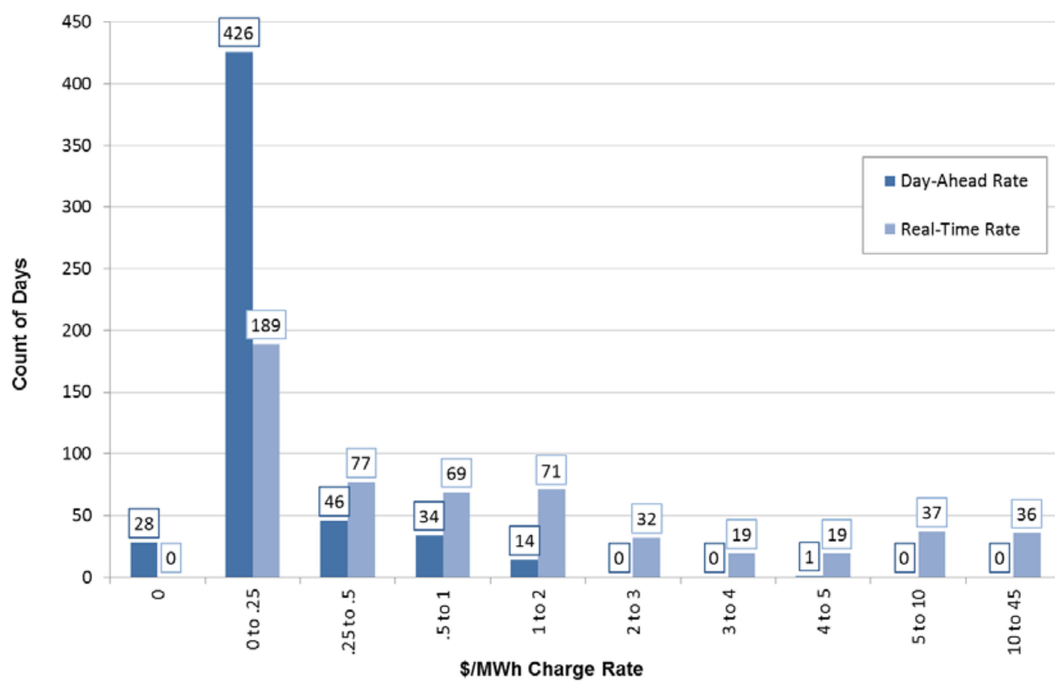
[27] In this section, real-time PJM rates are the RTO RT Deviations rate. Because some uplift charges are allocated RTO-wide while others are allocated regionally, rates for East and West regions do not add up to RTO-wide rates. Different types of commitments are allocated to the deviation and reliability categories. Although the following is not exhaustive, units committed as part of a reliability analysis to meet forecasted real-time load are allocated to deviations. Units committed as part of a reliability analysis due to extenuating conditions are allocated to reliability. Additionally, if a unit is called to operate during the operating day and the locational marginal price for that unit does not exceed the unit's cost for at least four, five-minute intervals of at least one clock hour, the costs are allocated to reliability. In the previous example, when the locational marginal price does exceed the unit's cost for at least four, five-minute intervals of at least one clock hour, the costs are allocated to deviations.

Figure 11: Frequency of Daily Uplift Charge Rates in MISO (2009-2013)



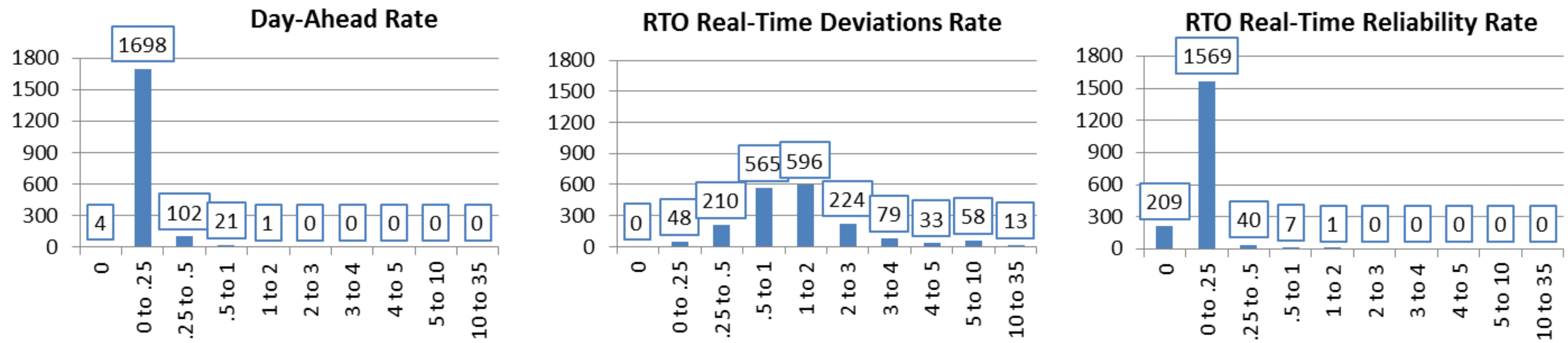
Notes: Hourly data for 2009-2013 has been transformed into a simple daily average. Several real-time charge rates were used. Beginning 1/1/2009, the RT_RSG_DIST value was utilized. Following a market change taking effect on 4/1/2011, the MISO_DDC_RATE was utilized. Maximum daily average real-time rate of $9.61/MWh was observed on 7/17/2012. Maximum daily average day-ahead Rate of $0.29/MWh was observed on 6/8/2011.
Data source: https://www.misoenergy.org/Library/MarketReports/Pages/MarketReports.aspx, report name "Revenue Sufficiency Guarantee."

Figure 12: Frequency of Daily Uplift Charge Rates in ISO-NE (2012-2013)

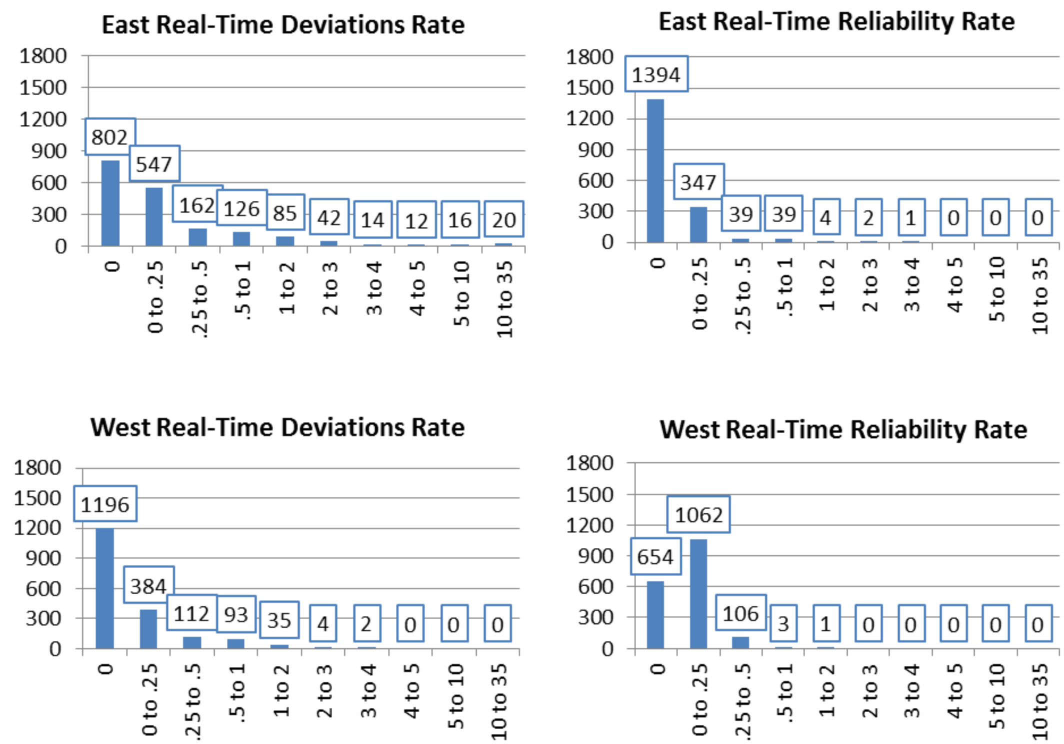


Notes: Analysis covers the period July 1, 2012 through December 31, 2013. Data source: Order No. 760.
Maximum real-time rate of $44.38/MWh was observed on 3/2/2013. Maximum day-ahead rate of $4.11MWh was observed on 12/31/2013.

Figure 13: Frequency of Daily Uplift Charge Rates in PJM (2009-2013)



Notes: Y axis represents a count of days. X axis respresent the uplift charge rate ($/MWh). Maximum day-ahead rate of $1.10/MWh was on 10/30/2012. Maximum RTO real-time deviations rate of $18.01/MWh was on 8/31/2012. Maximum real-time reliability rate of $1.61/MWh was on 1/24/2011. Maximum east real-time deviations rate of $32.88/MWh was on 2/9/2013. Data source: http://www.pjm.com/markets-and-operations/market-settlements/preliminary-billing-reports/ops-rates.aspx



V. Transparency

As noted elsewhere in this paper, there are numerous potential causes of uplift, some of which may not be transparent to the market. Failure to identify, make transparent, and price such causes can result in uplift credits that undermine the effectiveness of market signals and efficient system utilization and mute investment signals. The Commission's Electric Quarterly Report (EQR) has the potential to provide a great deal of detailed information regarding uplift.[28] Sellers with market-based rate authority are required to report on a quarterly basis uplift credits received by day and by resource location. If data are reported accurately with this level of granularity, some concerns about transparency could be addressed. However, EQR data does not make transparent the underlying system information or the market reasons a resource received uplift. As discussed below, there may be opportunities for the RTOs and ISOs and their respective MMUs to improve upon and augment reporting on uplift payments.

In an attempt to ascertain the usefulness of publicly-available data on uplift credits, a comparative analysis of two sources of information – public EQR and RTO and ISO reports and non-public data - was undertaken. The analysis involved the comparison of publicly-available EQR data to non-public RTO and ISO data from 2009-2013 and considered: (1) whether the magnitude of uplift credits received by a resource reported in the EQR was similar to uplift credits paid to each resource as reported in the non-public RTO and ISO data; and (2) the degree to which the two sources of data provided similar levels of locational information. In addition to the comparative analysis of EQR data to non-public RTO and ISO data, there is a qualitative assessment of the information on uplift as reported publicly by the RTOs and ISOs and MMUs.

A. A Comparison of Public and Non-Public Uplift Data

The non-public data are sufficiently granular in both location and time to allow an analysis of whether the information reported on a public basis is reported at the same level of granularity, and whether the public source provides sufficiently transparent and meaningful uplift information.

Certain entities, including those that received market-based rate authorization from the Commission, are required to file EQR reports with the Commission. These filings contain data on contracts and transactions for certain products, including uplift. Some entities, including certain cooperatives and municipalities, were not required to file EQRs

[28] *See Elec. Mkt. Transparency Provisions of Section 220 of the Fed. Power Act*, Order No. 768, FERC Stats. & Regs. ¶ 31,336 (2012), *order on reh'g*, Order No. 768-A, 143 FERC ¶ 61,054 (2013).

during the majority of the time period analyzed in this paper. Accordingly, while the EQR is believed to provide the most detailed public source of uplift data, not all uplift credits are reflected in the analysis.

A comparison of the aggregate uplift credits, reported as "sales" in market participants' EQRs, with total uplift credits found in non-public RTO and ISO data shows that the non-public RTO and ISO data contained roughly $200 million more in uplift credits each year than what was reported in the EQR (See Figure 14). EQR uplift credits in MISO were routinely about 15% below the RTO's figures. Potentially underreported uplift credits in PJM hovered around 20%, while in NYISO it varied between 29% and 49%. Some of the disparity between the two data sources may be attributable to certain entities not being required to report sales to the EQR, which is why EQR reported data for 2013 most closely matched RTO and ISO reported data.[29]

To ascertain the degree to which the two sources of information provide a similar level of transparency of uplift information, EQR data were compared to non-public RTO and ISO data on a location-specific basis.[30] Initially, the number of unique settlement locations that received uplift credits reported in the EQR was compared to settlement locations in the non-public RTO and ISO data. In all cases, as seen in Figure 15, non-public RTO and ISO data contained additional settlement location granularity. Specifically, for MISO, NYISO and ISO-NE markets, the EQR data generally contained 70% to 80% of unique settlement locations found in RTO and ISO data. Unique settlement location instances in CAISO- and PJM-related EQR data were significantly fewer than in RTO and ISO data.[31]

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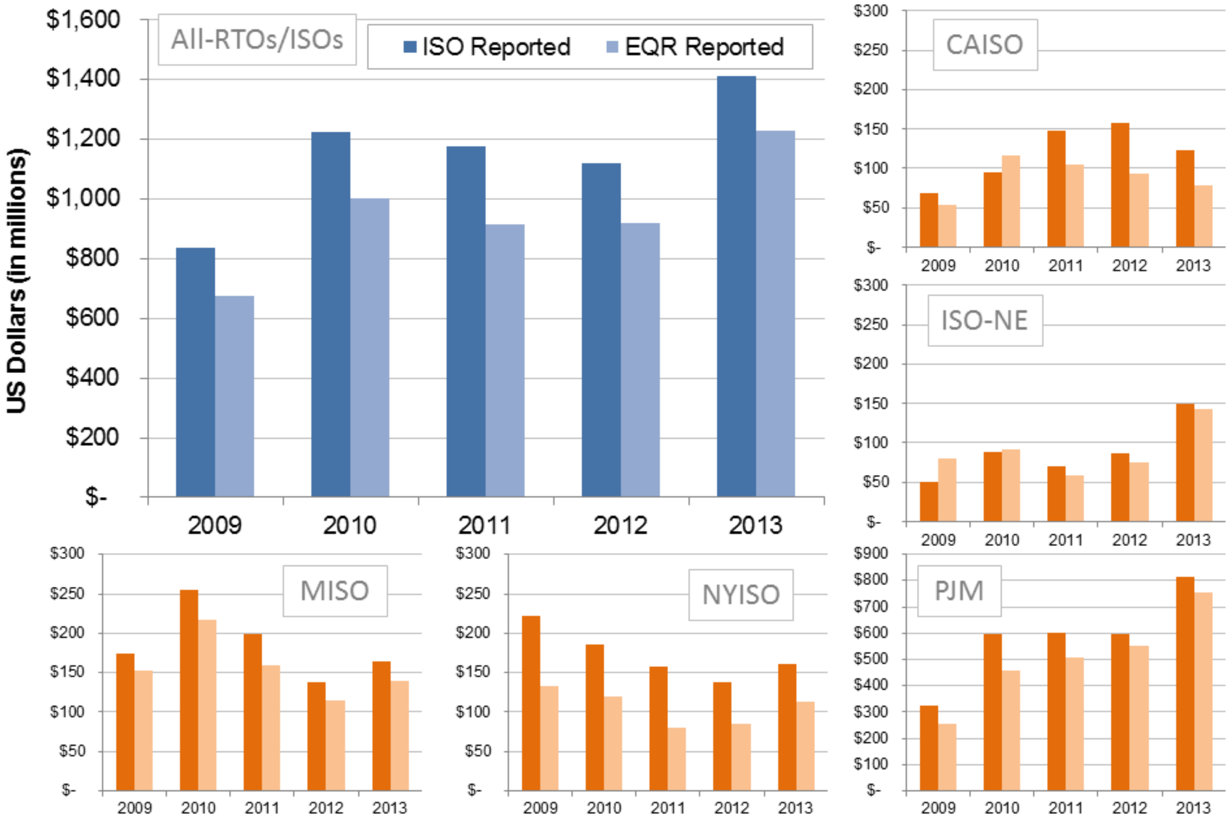
[29] Cooperative and municipal utilities are now required to file EQRs for transactions that occur on or after July 1, 2013. EQR totals for 2013 were queried on June 2, 2014 and, therefore, may not have captured updated 2013 data reported after that date. Additionally, approximately 15% of historic filers had not filed EQR reports for the second half of 2013 by June 2, 2014.

[30] RTO and ISO data contained unique settlement locations for each resource receiving uplift credits; these were generally reflected in price node names or price node IDs. Unique settlement locations were identified for transactions reported in the EQR using the "Point of Delivery Specific Location (PODSL)" field. PODSL locations are not standardized in the EQR but are supposed to match the location specified in the contract. Per the EQR data dictionary, the PODSL is "the specific location at which the product is delivered if designated in the contract. If receipt occurs at a trading hub, a standardized hub name must be used."

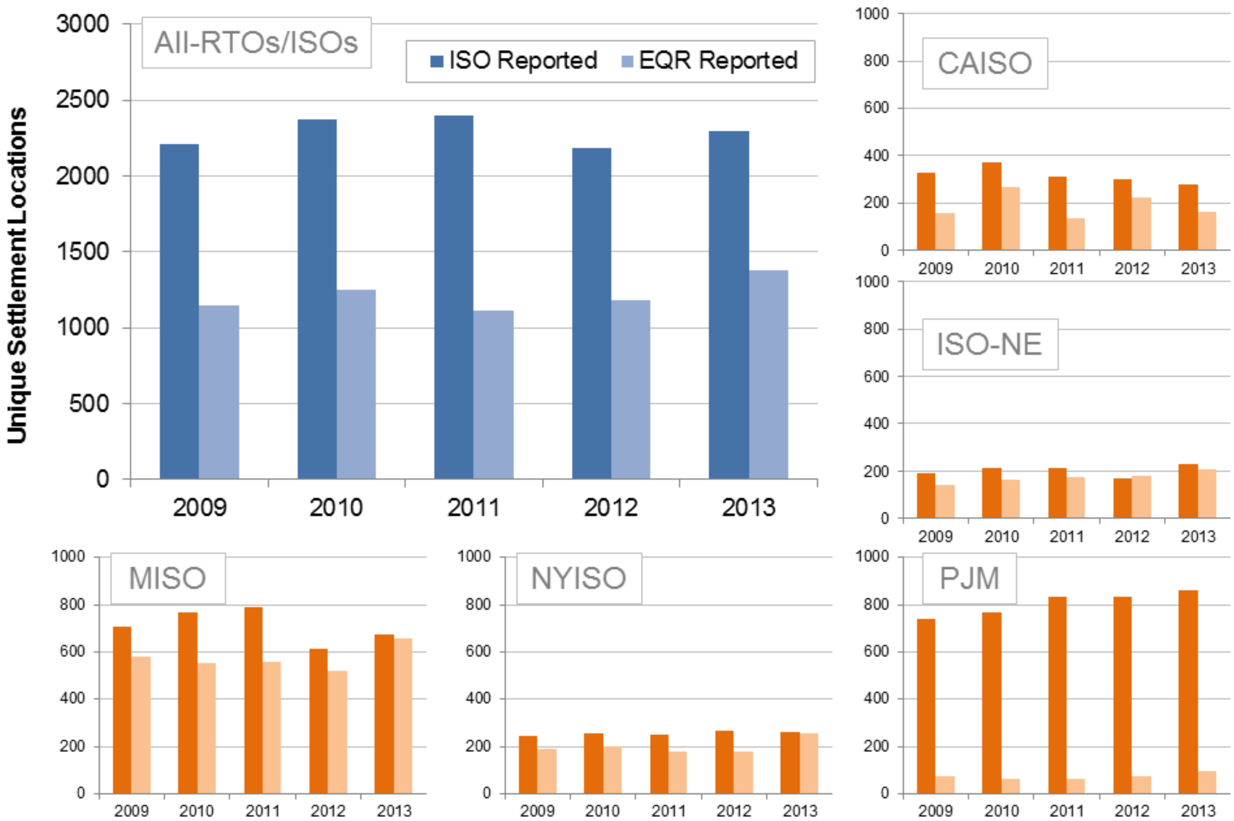
[31] Each of the RTOs and ISOs, with the exception of CAISO, prepares a pre-formatted, EQR-ready report for their market participants containing information on sales made to the RTO or ISO, including uplift credits for which a market participant received payment. Each EQR filer may incorporate each RTO's or ISO's report along with additional data into its quarterly filing. Thus, even though individual filers bear responsibility for the timeliness and accuracy of their filings, the quality of information may, in many cases, reflect how each RTO or ISO prepares these pre-formatted, EQR-ready reports. In the case of CAISO, the divergence may be due to the lack of a pre-formatted, EQR-ready report being generated by CAISO; meaning that decisions on how to report settlement locations are entirely left to individual filers. Over 90% of the value of uplift credits reported in EQRs as sales in PJM provides no specific settlement location information, which may result from PJM's pre-formatted, EQR-ready report. One way to improve the quality of EQR reports could be for the RTOs or ISOs to adjust the data provided in their EQR-ready reports. In the case of CAISO, this would entail the creation of a new report.

Figure 14: RTO/ISO Reported vs. EQR Reported Annual Uplift Credits



Note: Figure represents total annual uplift credits ($ million). 2009 total credits for CAISO reflect 9 months of uplift. Total credits for ISO-NE are based on estimated data for 2012. Total credits for PJM for 2012-2013 exclude reactive services (approximately $45 million/year).

Figure 15: RTO/ISO Reported vs. EQR Reported Settlement Location Granularity



Note: EQR Unique settlement locations were identified using Point of Delivery Specific Location field. The data reported by MISO (RTO/ISO data) does not include real-time revenue sufficiency guarantee locations for 2012-2013. The data reported by ISO-NE for 2012 is only for the second half of the year.

With the unique settlement locations identified, sales data from the EQR and RTO and ISO data sources were matched and compared. Figure 16 shows the percentage of EQR-reported uplift credits that were matched to unique RTO and ISO settlement locations. Most of the ISO-NE, MISO and NYISO and some of the CAISO locations reported in the EQR contained sufficient descriptions of that location to allow them to be readily traced to an RTO and ISO settlement location.[32] Very few of the PJM locations could be attributed to discrete locations.

[32] The majority of the CAISO non-matched locations in 2010 and 2011 were reported in the EQR at SP-15.

Figure 16: Percentage of EQR Reported Uplift Credits Matchable to a Unique RTO/ISO Settlement Location

	2009	2010	2011
CAISO	63%	39%	83%
ISO-NE	76%	95%	98%
MISO	91%	96%	97%
NYISO	93%	93%	94%
PJM	8%	6%	6%

The total values of uplift credits in dollars were then compared at the matched locations. As seen in Figures 14 and 16, the MISO EQR figures most closely matched the RTO's data, while the other RTOs and ISOs occasionally had some very significant differences. Figure 17 shows the total percentage difference between EQR and RTO and ISO uplift credit data at only the matched locations. The figure for MISO may be interpreted to mean that EQR reported uplift credit totals were 1% higher, 2% lower and 3% higher than RTO and ISO credit totals in 2009, 2010, and 2011, respectively. This figure, however, does not account for differences at each settlement location but looks at the total for all matched locations.[33] Positive differences between the data for some locations may offset negative differences for other locations, masking absolute differences.

Figure 17: Percentage Difference Between EQR and RTO/ISO Reported Uplift Credits at Matched Locations (RTO/ISO wide)

	2009	2010	2011
CAISO	-20%	17%	9%
ISO-NE	-31%	-12%	10%
MISO	1%	-2%	3%
NYISO	13%	2%	17%
PJM	9%	1%	0%

[33] The total for all matched locations is a computation of the difference between EQR-reported uplift and uplift from the RTO and ISO data for each location with differences summed across locations.

This analysis was further refined to assess the absolute value differences between EQR and RTO and ISO data at each matched settlement location and weighted any divergences using total sales at that location, as found in RTO and ISO data. After accounting for these factors, EQR uplift data in every RTO and ISO, and most notably for CAISO, often diverged significantly from RTO and ISO reported uplift data. See Figure 18.

Figure 18: Percentage Difference Between EQR and RTO/ISO Reported Uplift Credits at Matched Locations (RTO/ISO wide)

	2009	2010	2011
CAISO	62%	30%	17%
ISO-NE	47%	25%	15%
MISO	16%	8%	5%
NYISO	15%	3%	18%
PJM	9%	3%	22%

As noted above, the EQR data have the potential to provide valuable information on uplift credits by location and by day. However, the data suggest that EQR reporting, especially for sellers in PJM and CAISO, may not be providing substantially useful or accurate transparency. This is particularly true with respect to the location of the resource receiving uplift credits. Using EQR data to provide transparency on uplift credits and charges has limitations including limited background information on the type of uplift or the reason for incurring the uplift reported in the EQR. This information may be important when market participants and other stakeholders assess market-based solutions to uplift.

B. Publicly Available RTO and ISO and MMU Uplift Data

This section focuses primarily on the degree to which RTOs and ISOs and their respective MMUs provide summary information, with some high-level discussion of the degree to which RTOs and ISOs add context to the data reported. RTOs and ISOs have the opportunity to provide additional transparency in several ways. First, RTOs and ISOs can provide summary data on uplift credits so that it is not necessary to review all the EQR filings for an RTO or ISO in order to understand general trends. Second, RTOs and ISOs can provide additional context, commentary or trends analysis for summary information provided. Third, RTOs and ISOs have information about the causes of uplift that is not reported in EQRs.

In general, publicly posted information by RTOs and ISOs and their MMUs provides useful background on trends in uplift credits.[34] There are routine data postings on uplift by each RTO and ISO. MMUs summarize uplift credits and charges in their annual and sub-annual reports. Uplift credit data from both sources, as shown in Figure 19, is usually reported at system-wide levels, with only PJM and NYISO's MMU reporting at a zonal level. When reporting is more granular, aggregation has occurred at a regional level, whether by zone(s), hub or intertie.

Figure 19: Uplift Credit Location Reporting

MMU	**CAISO**	System-Wide
	ISO-NE	System-Wide
	MISO	System-Wide
	NYISO	5 aggregate locations (zones A-G, F-I, J, and K and interties)
	PJM	Zones, hubs, and interties
RTO	**CAISO**	System-Wide for BCR, Local Reliability Area for Exceptional Dispatch
	ISO-NE	System-Wide
	MISO	System-Wide
	NYISO	Zones and some unit level reporting
	PJM	System-Wide and some zone level reporting

The lack of location specificity may limit the usefulness of publicly-posted data, particularly with respect to investment decisions.[35] Information on the category of uplift credit is generally included in these postings; categories often reflect charge codes or identify the market in which the uplift credits were incurred (e.g., day-ahead).

RTO and ISO and MMU uplift data postings also do not tend to include information about reasons for incurring uplift credits, with several exceptions.[36] The CAISO posted exceptional dispatch report lists reasons for utilizing exceptional dispatches, including: intertie emergency assistance, conditions beyond the control of the CAISO, load forecast uncertainty, software limitations, and references to certain procedure numbers, among

[34] This analysis looked at both internal and external MMUs when applicable.

[35] The PJM MMU recently recommended revising uplift confidentiality rules in order to allow disclosure of complete information about the level of operating reserve charges by unit and the detailed reason for the level of operation reserve payment by unit. Monitoring Analytics, 2013 State of the Market Report for PJM, March 13, 2014 at http://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2013/2013-som-pjm-volume2-sec4.pdf.page 123.

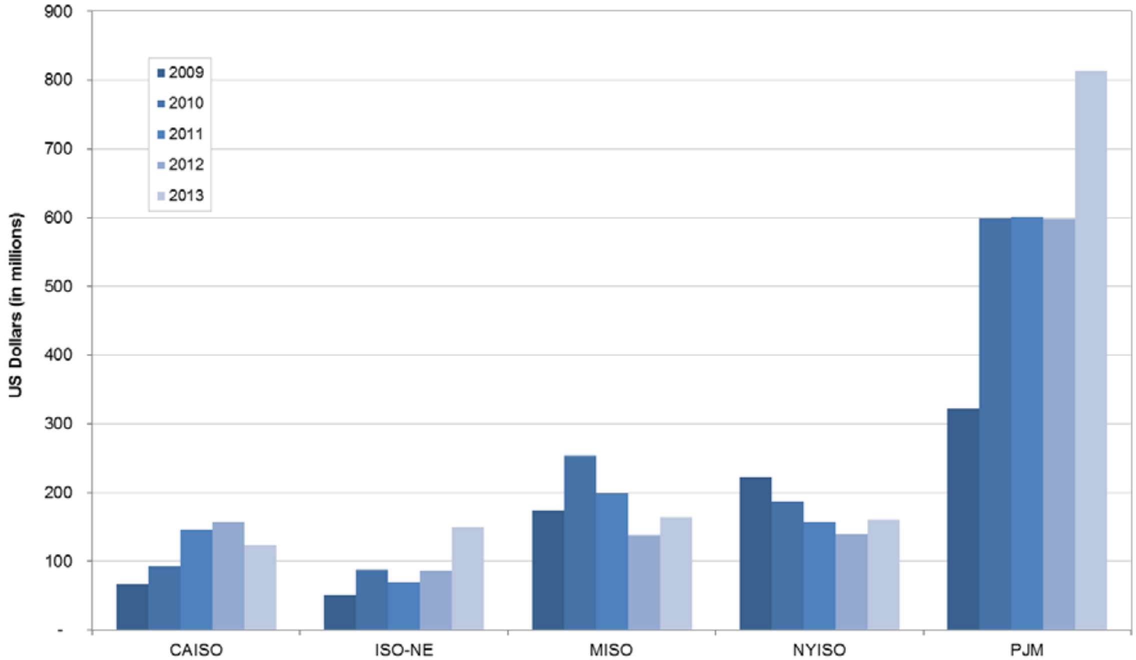
[36] For example, charge codes may highlight that a resource received uplift while operating to resolve a real-time reliability issue. However, charge codes are designed to be generic and do not contain information on the specific reliability issue the unit was called on to resolve.

others. The MISO MMU report generally states whether the uplift was due to voltage, capacity or congestion needs and whether the credit was designed to reimburse energy or commitment costs. Finally, the PJM MMU reports 17 different categories, some of which include the reason a credit was paid, such as black start services. To varying degrees, all of the MMUs provide context on the reason for some uplift credits.

With added transparency, market participants and other stakeholders are in the best position to develop solutions to address the causes giving rise to uplift. For instance, knowing that the vast majority of uplift in a particular import-constrained zone is related to the provision of reactive power could make clear to market participants that the zone is reactive power deficient. This could lead to proposals to address reactive power compensation and potentially send a price signal to enhance reactive power capability. On the other hand, knowing that a majority of uplift in a particular zone is related to local "reliability" could suggest that the model is not incorporating certain constraints or the operators are conservatively committing units to address generic concerns. In either case, this raises the possibility that energy prices do not fully reflect the marginal cost of production. Further, enhancing the transparency of the cost of such local reliability concerns may provide information necessary to appreciate the full cost of managing such local reliability concerns and to consider alternative solutions. This is particularly important when uplift costs are allocated in a manner different than the cost of alternative solutions.

Appendix A

Figure A.1: Total Annual Uplift Credit by RTO and ISO



Note: Total uplift credits for 2009 for CAISO is for 9 months, beginning 4/1/2009. Total uplift credits for 2012 for ISO-NEwere estimated. Total uplift credits for PJM for 2012-2013 excludes reactive services (aproximately $45 million per year).

Figure B.1: Concentration of Uplift Credits by Plant in 2009

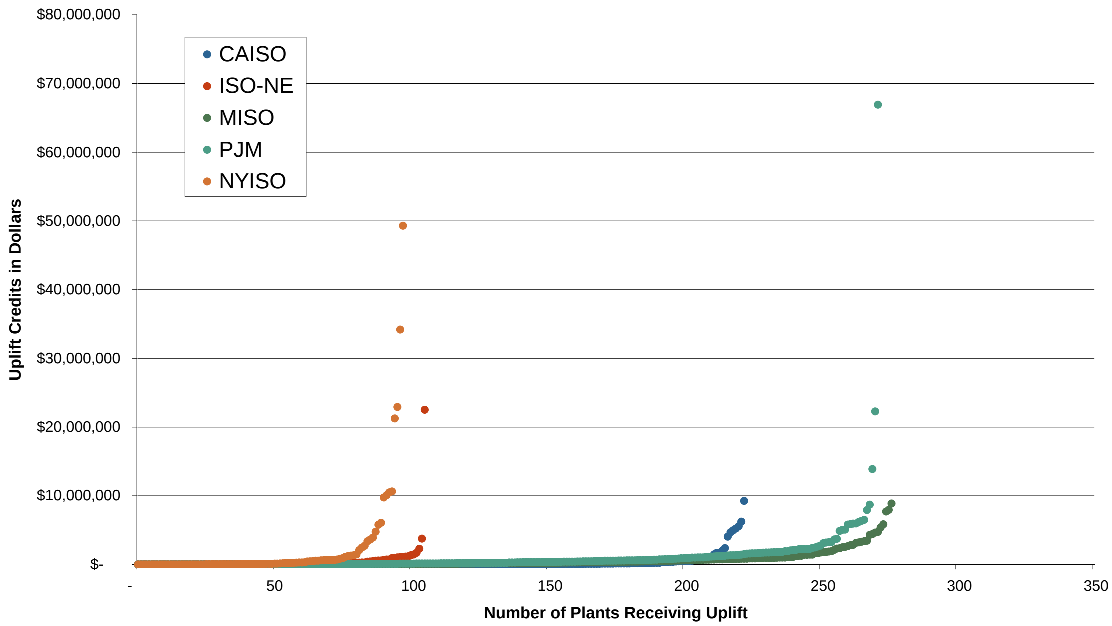


Figure B.2: Concentration of Uplift Credits by Plant in 2010

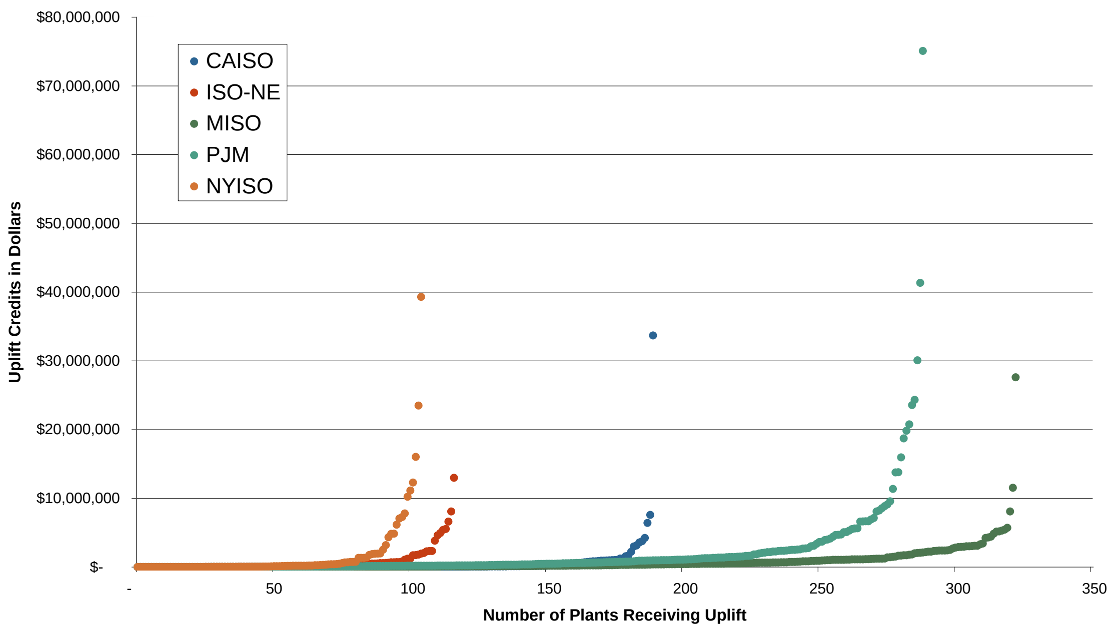


Figure B.3: Concentration of Uplift Credits by Plant in 2011

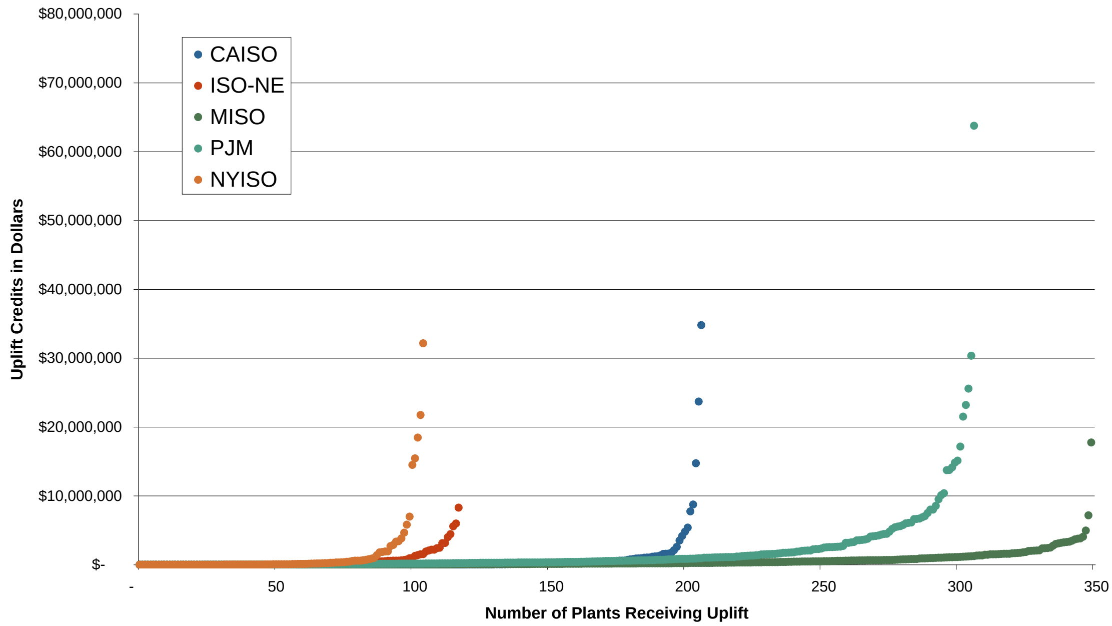
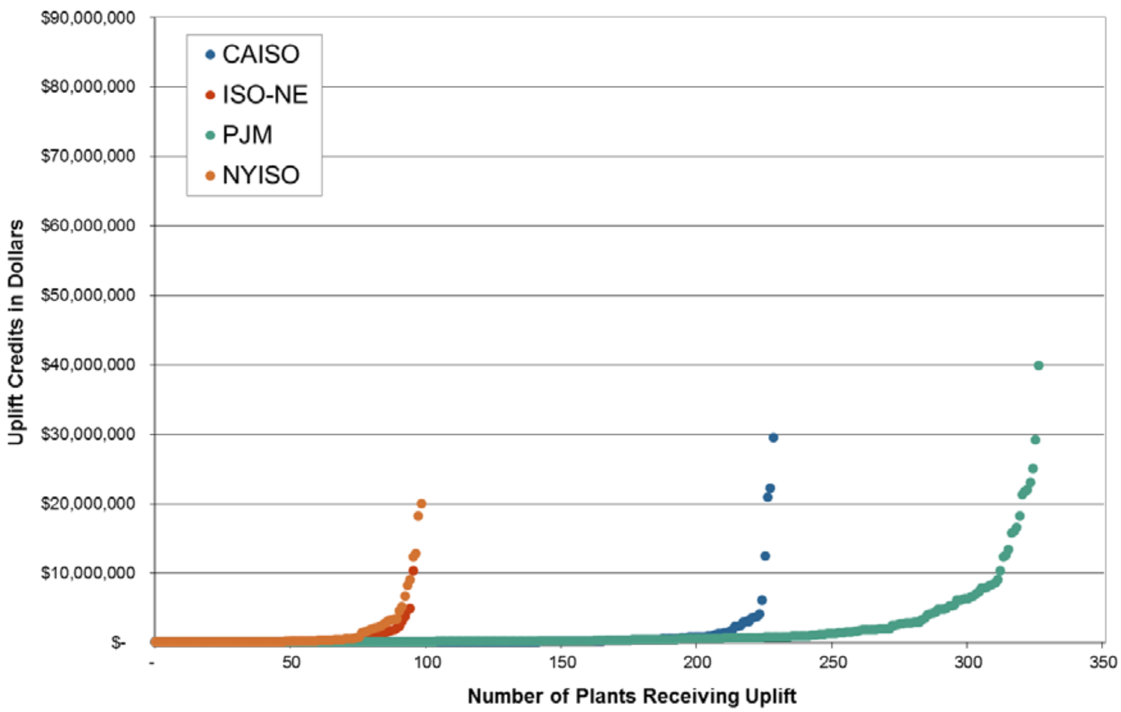
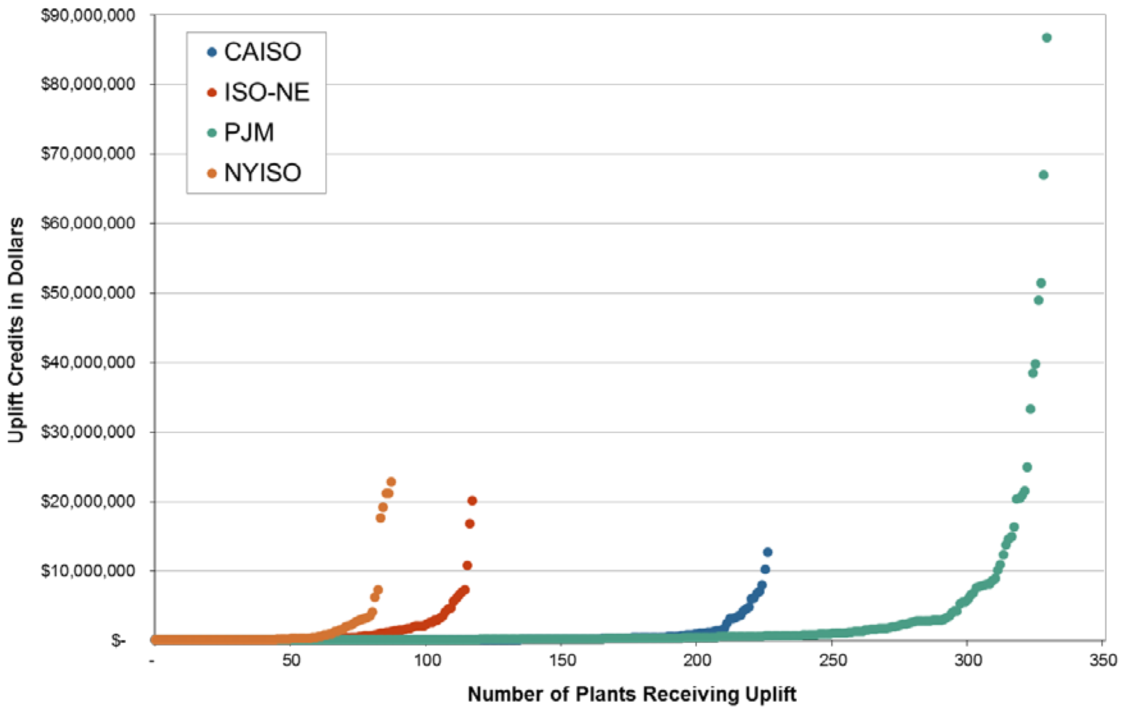


Figure B.4: Concentration of Uplift Credits by Plant in 2012



Note: Uplift payment totals have not been included for MISO in 2012 or 2013 and do not include reactive services related uplift for PJM. Totals for ISO-NE in 2012 only represent the third and fourth quarter.

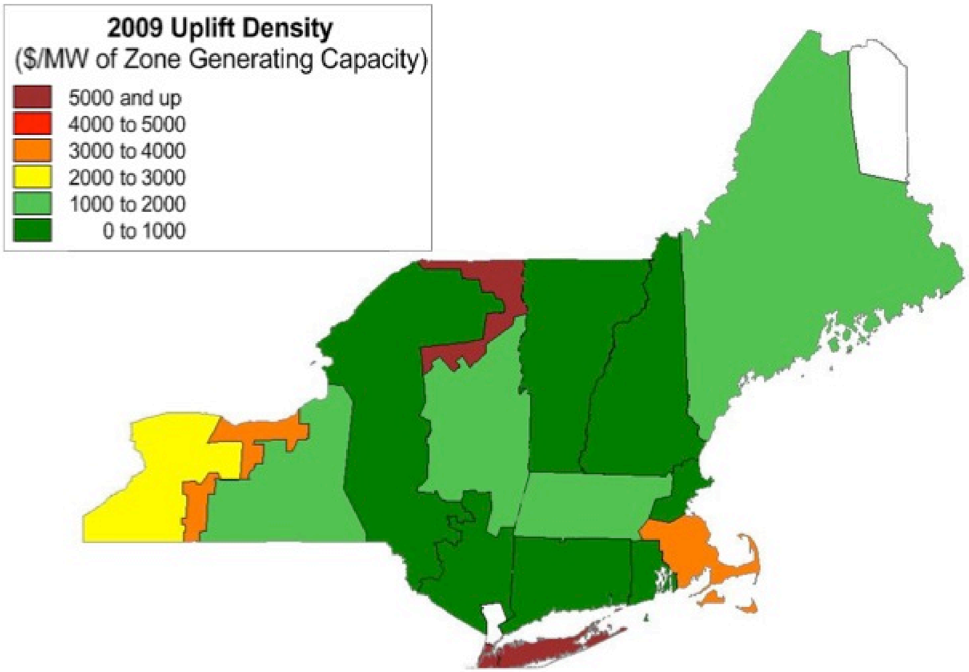
Figure B.5: Concentration of Uplift Credits by Plant in 2013



Note: Uplift payment totals have not been included for MISO in 2012 or 2013 and do not include reactive services related uplift for PJM. Totals for ISO-NE in 2012 only represent the third and fourth quarter.

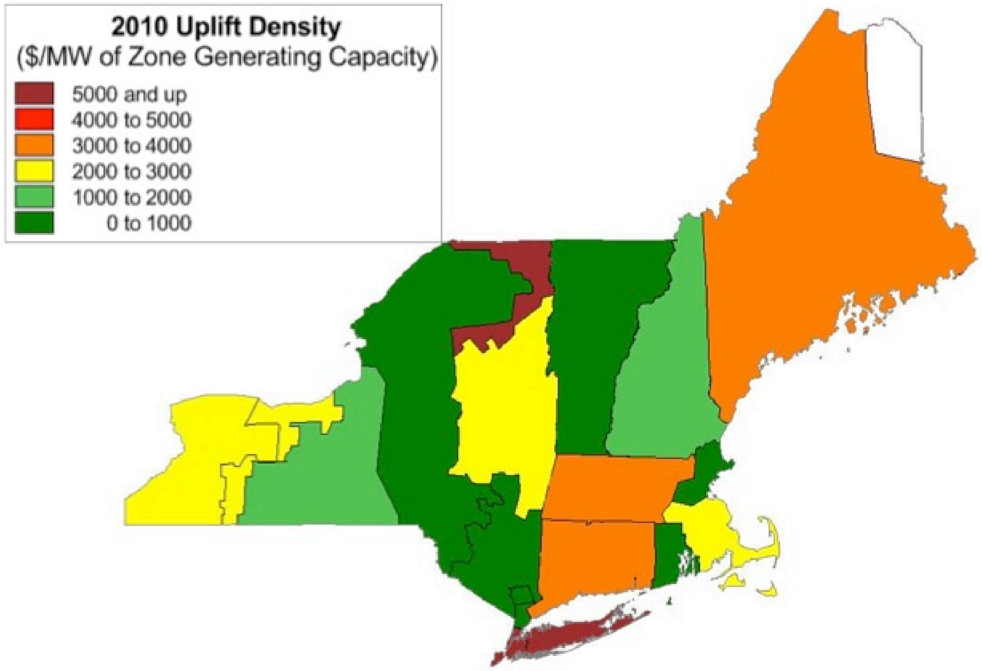
Appendix C

Figure C.1: NYISO and ISO-NE 2009 Uplift Credits Mapped by Region



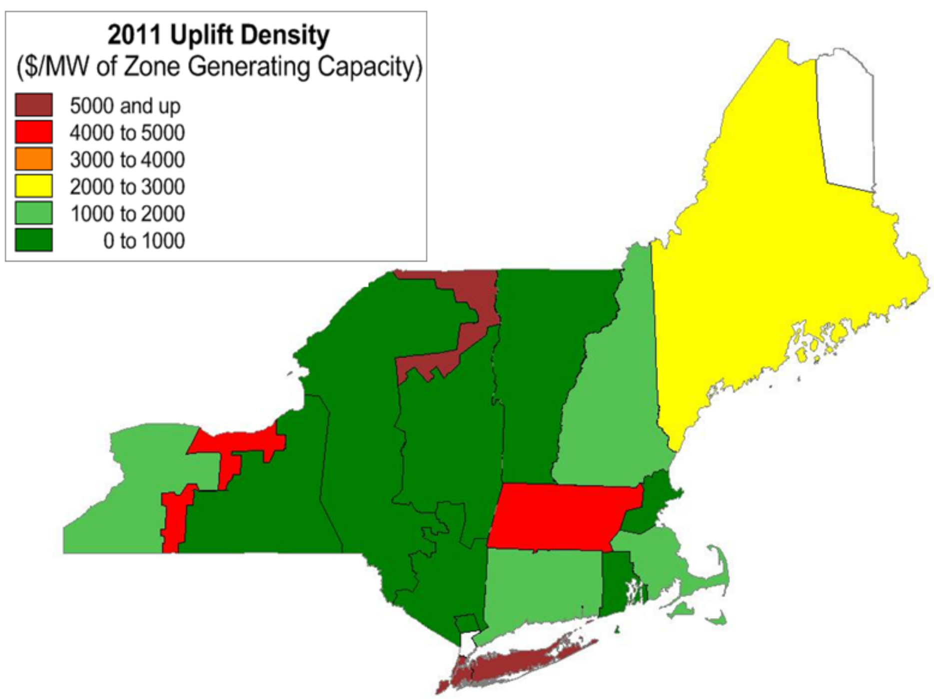
Note: "Uplift Density" is defined as the total annual uplift ($) per MW of generating capacity. Capacity figure was calculated using Ventyx.

Figure C.2: NYISO and ISO-NE 2010 Uplift Credits Mapped by Region



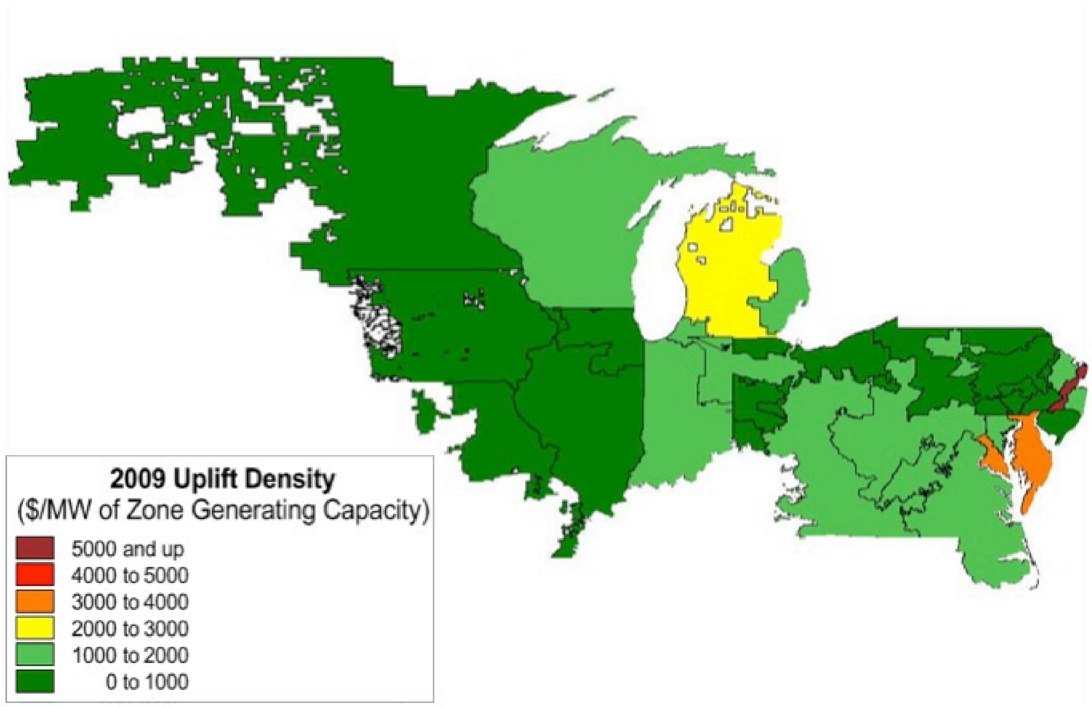
Note: "Uplift Density" is defined as the total annual uplift ($) per MW of generating capacity. Capacity figure was calculated using Ventyx.

Figure C.3: NYISO and ISO-NE 2011 Uplift Credits Mapped by Region



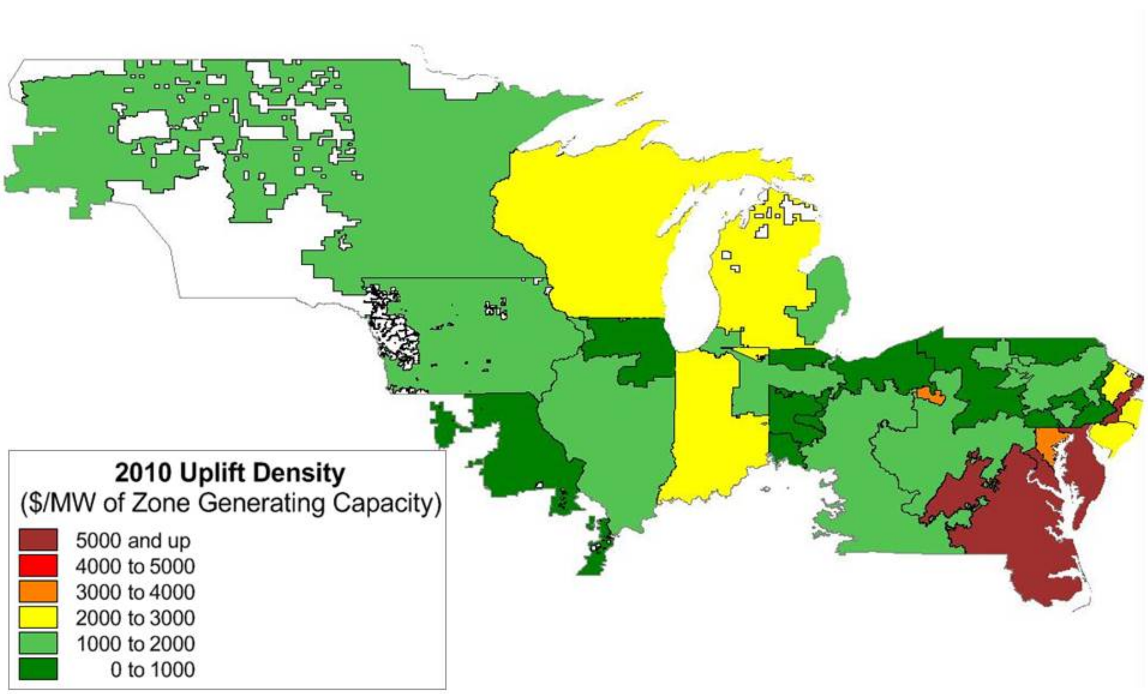
Note: "Uplift Density" is defined as the total annual uplift ($) per MW of generating capacity. Capacity figure was calculated using Ventyx.

Figure C.4: PJM and MISO 2009 Uplift Credits Mapped by Region



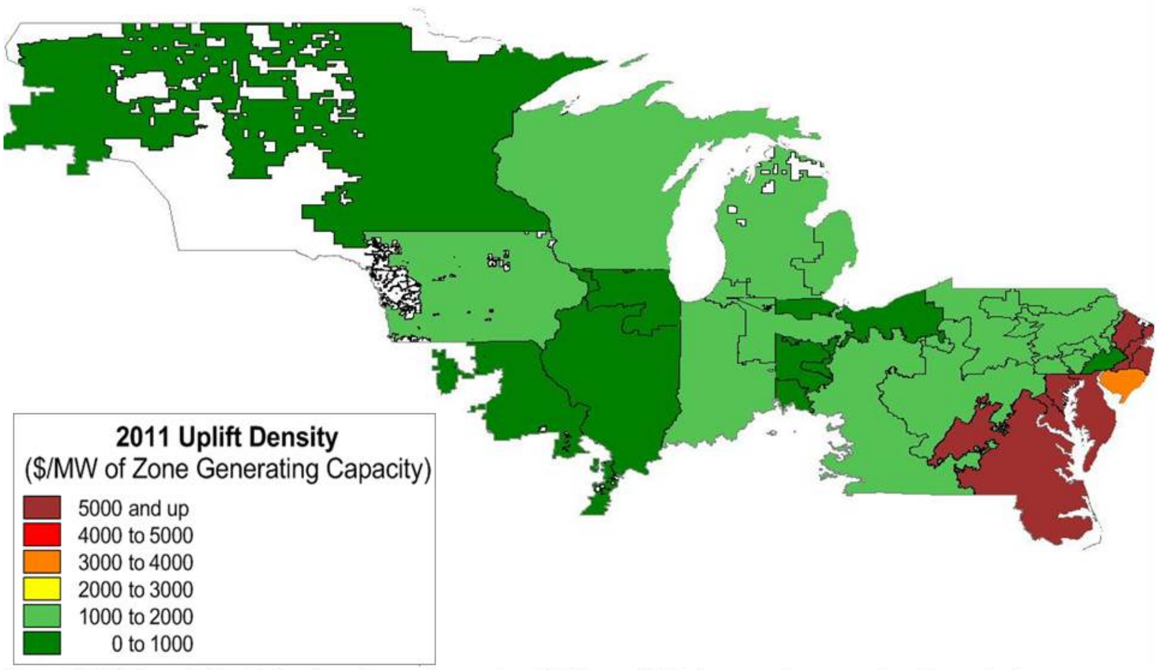
Note: "Uplift Density" is defined as the total annual uplift ($) per MW of generating capacity. Capacity figure was calculated using Ventyx.

Figure C.5: PJM and MISO 2010 Uplift Credits Mapped by Region



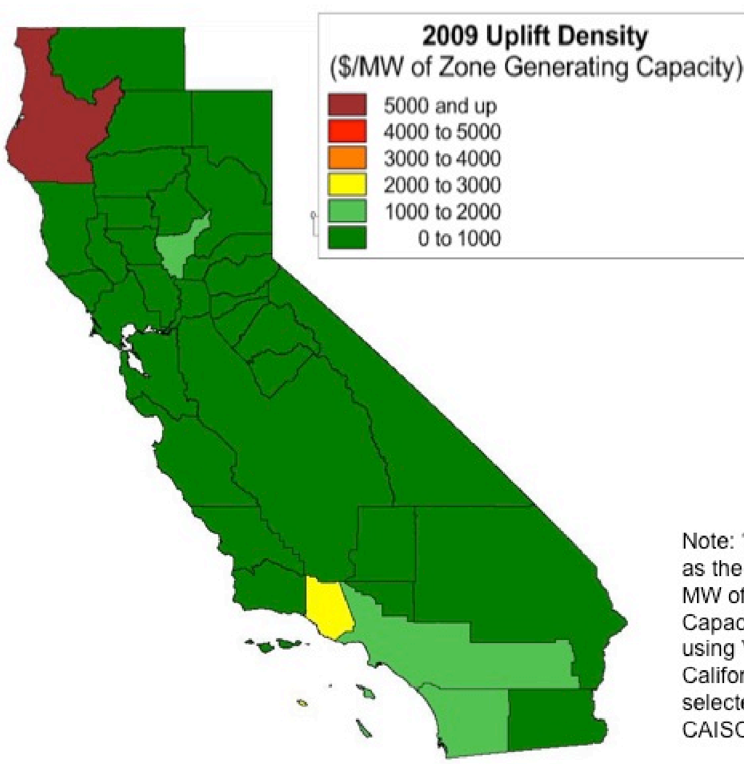
Note: "Uplift Density" is defined as the total annual uplift ($) per MW of generating capacity. Capacity figure was calculated using Ventyx.

Figure C.6: PJM and MISO 2011 Uplift Credits Mapped by Region



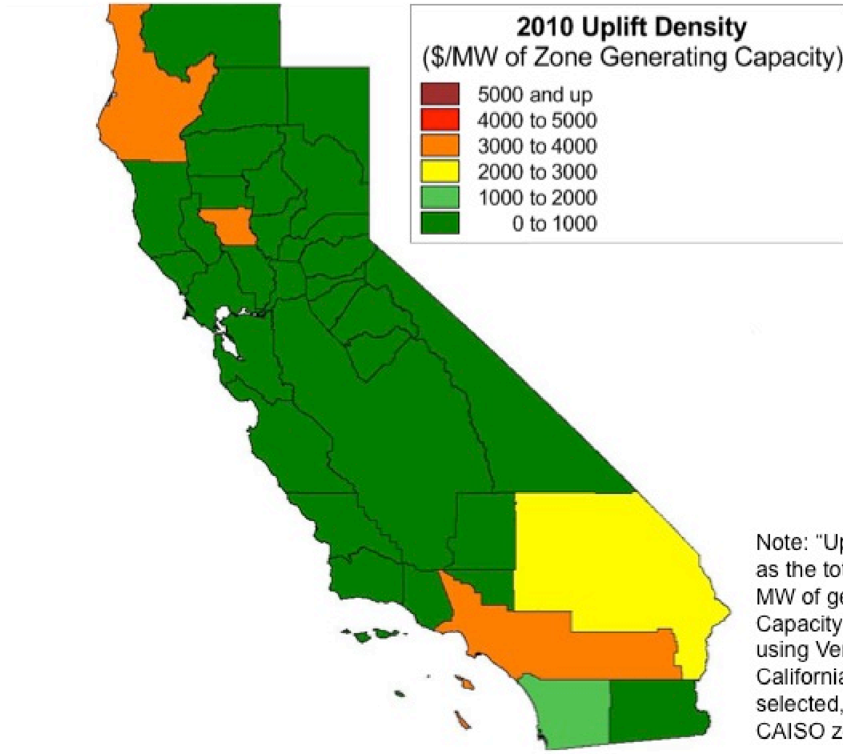
Note: "Uplift Density" is defined as the total annual uplift ($) per MW of generating capacity. Capacity figure was calculated using Ventyx.

Figure C.7: CAISO 2009 Uplift Credits Mapped by Region



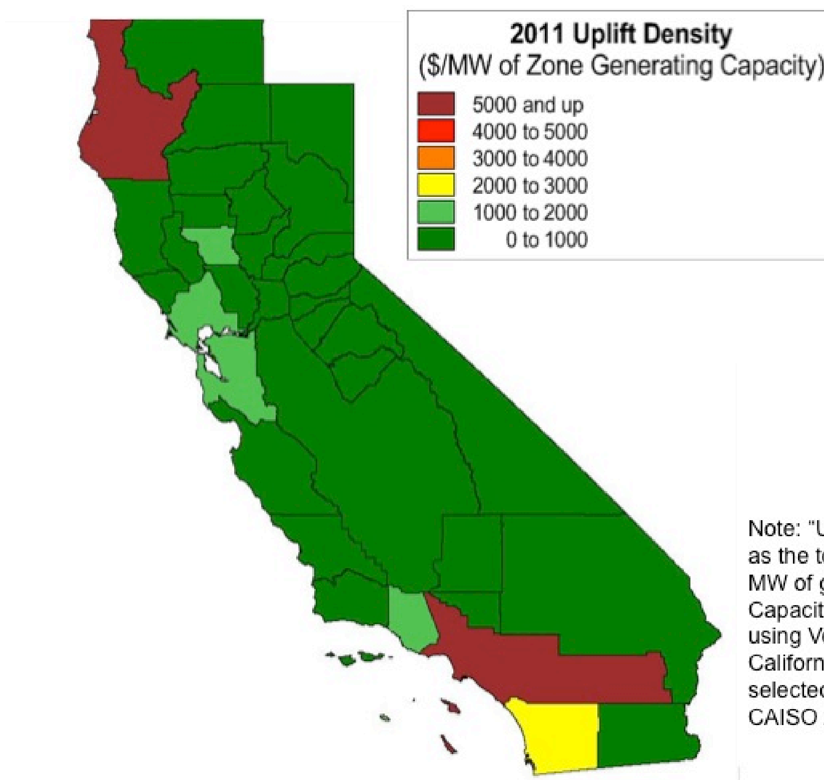
Note: "Uplift Density" is defined as the total annual uplift ($) per MW of generating capacity. Capacity figure was calculated using Ventyx. For CAISO, the California AQM district was selected, rather than individual CAISO zones.

Figure C.8: CAISO 2010 Uplift Credits Mapped by Region



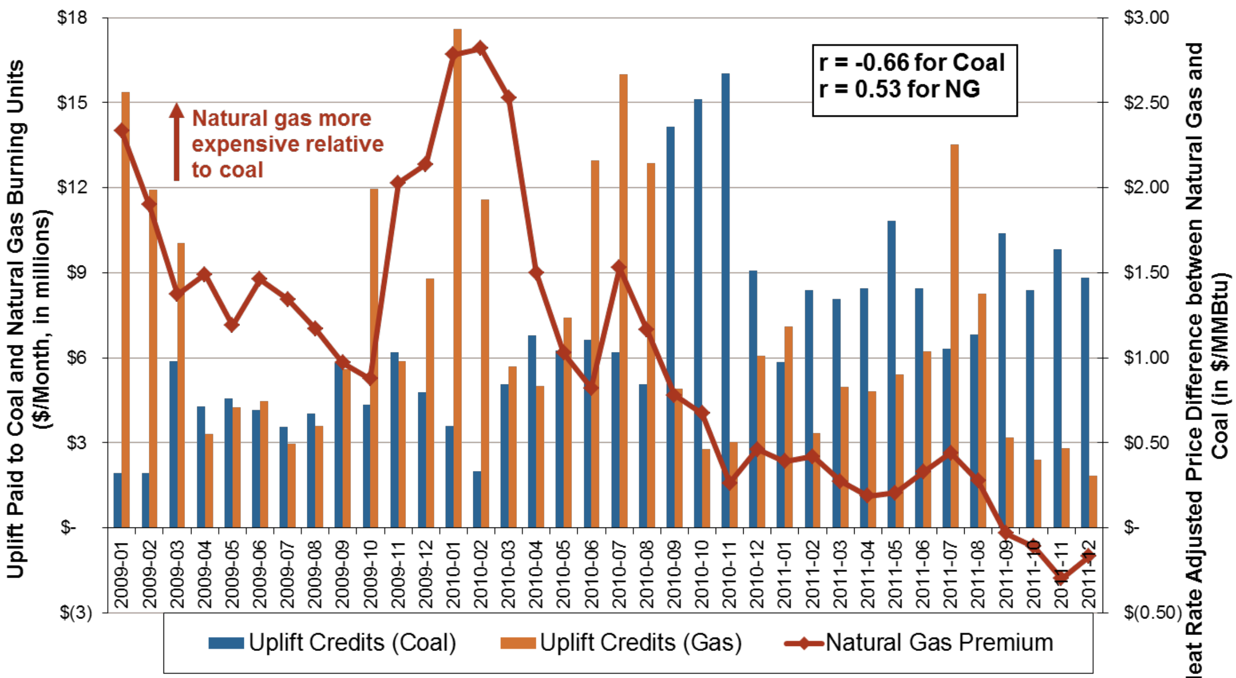
Note: "Uplift Density" is defined as the total annual uplift ($) per MW of generating capacity. Capacity figure was calculated using Ventyx. For CAISO, the California AQM district was selected, rather than individual CAISO zones.

Figure C.9: CAISO 2011 Uplift Credits Mapped by Region



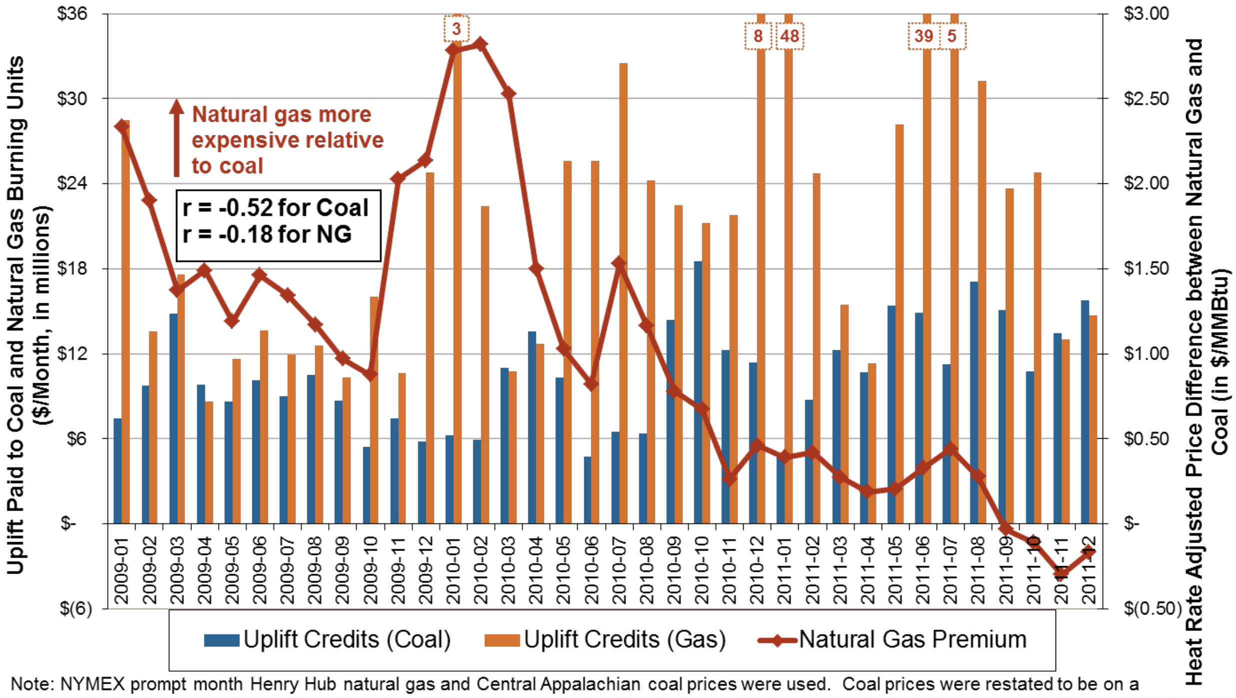
Note: "Uplift Density" is defined as the total annual uplift ($) per MW of generating capacity. Capacity figure was calculated using Ventyx. For CAISO, the California AQM district was selected, rather than individual CAISO zones.

Figure D.1: Uplift Credits to Coal and Gas Burning Units in MISO



Note: NYMEX prompt month Henry Hub natural gas and Central Appalachian coal prices were used. Coal prices were restated to be on a comparable basis to natural gas prices given the relative difference in fleet heat rates and fuel energy output. A Pearson correlation coefficient (r) was used to assess for correlation between monthly fuel prices and uplift credits.

Figure D.2: Uplift Credits to Coal and Gas Burning Units in PJM



Note: NYMEX prompt month Henry Hub natural gas and Central Appalachian coal prices were used. Coal prices were restated to be on a comparable basis to natural gas prices given the relative difference in fleet heat rates and fuel energy output. A Pearson correlation coefficient (r) was used to assess for correlation between monthly fuel prices and uplift credits.

Figure D.3: Total Annual Uplift Credits ($ million) by Fuel Type in 2011

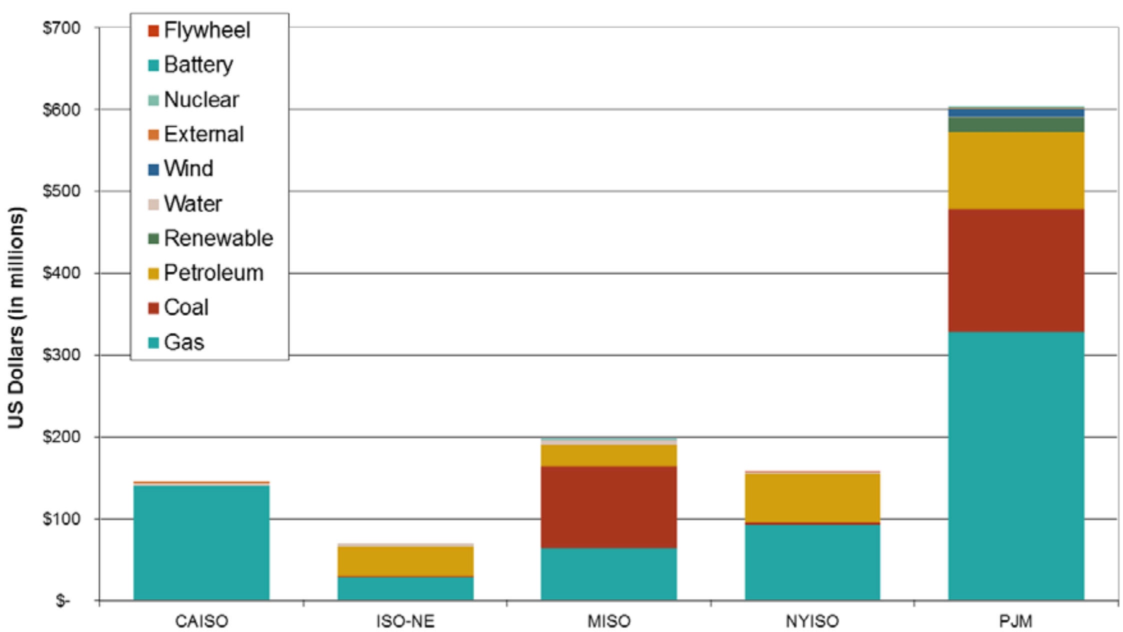
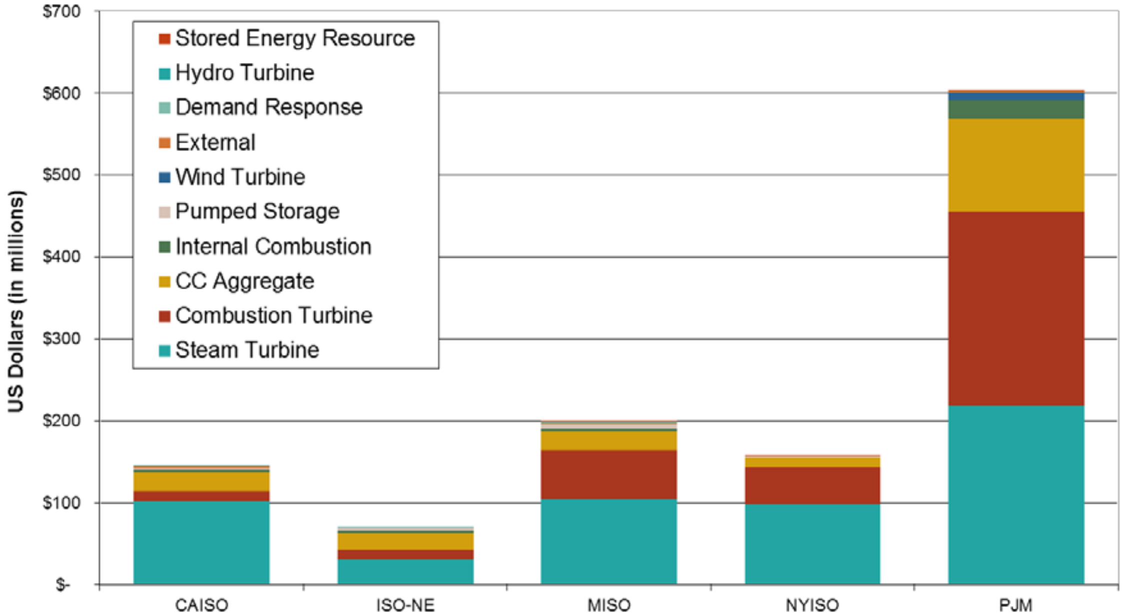
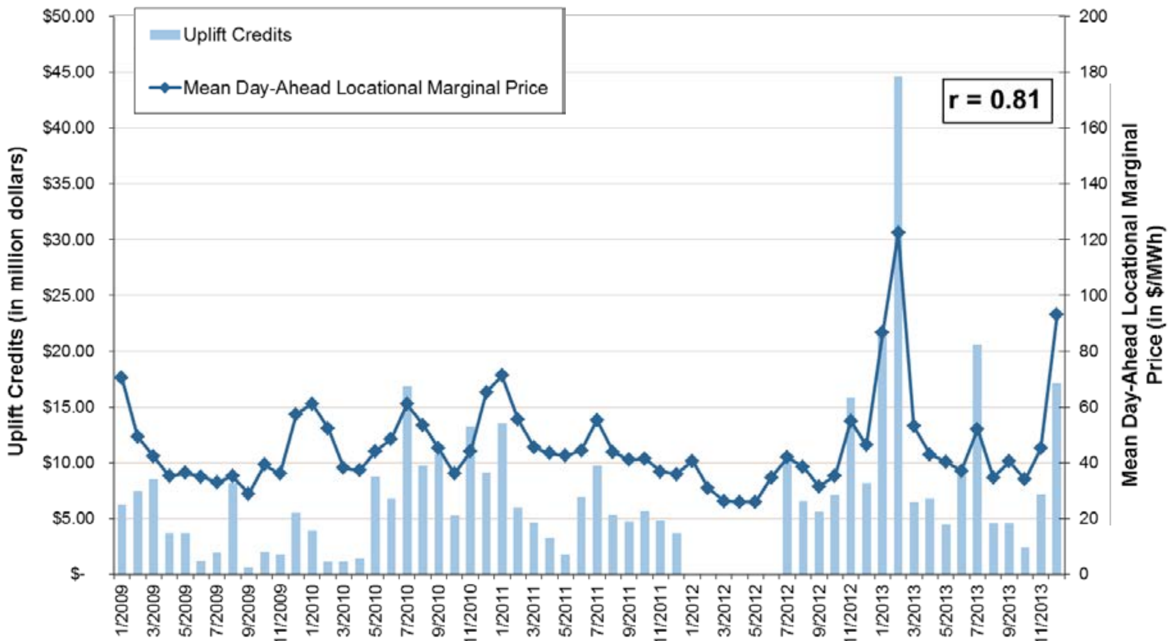


Figure D.4: Total Annual Uplift Credits ($ million) by Prime Mover in 2011



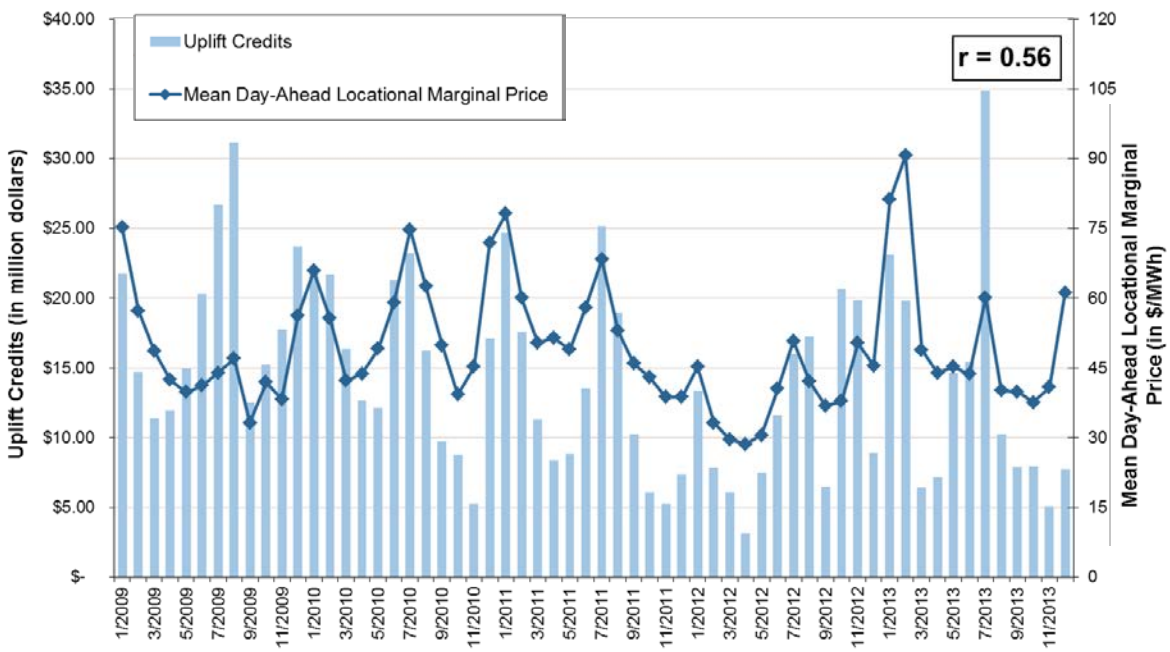
Appendix E

Figure E.1: Uplift and LMP Correlation in ISO-NE



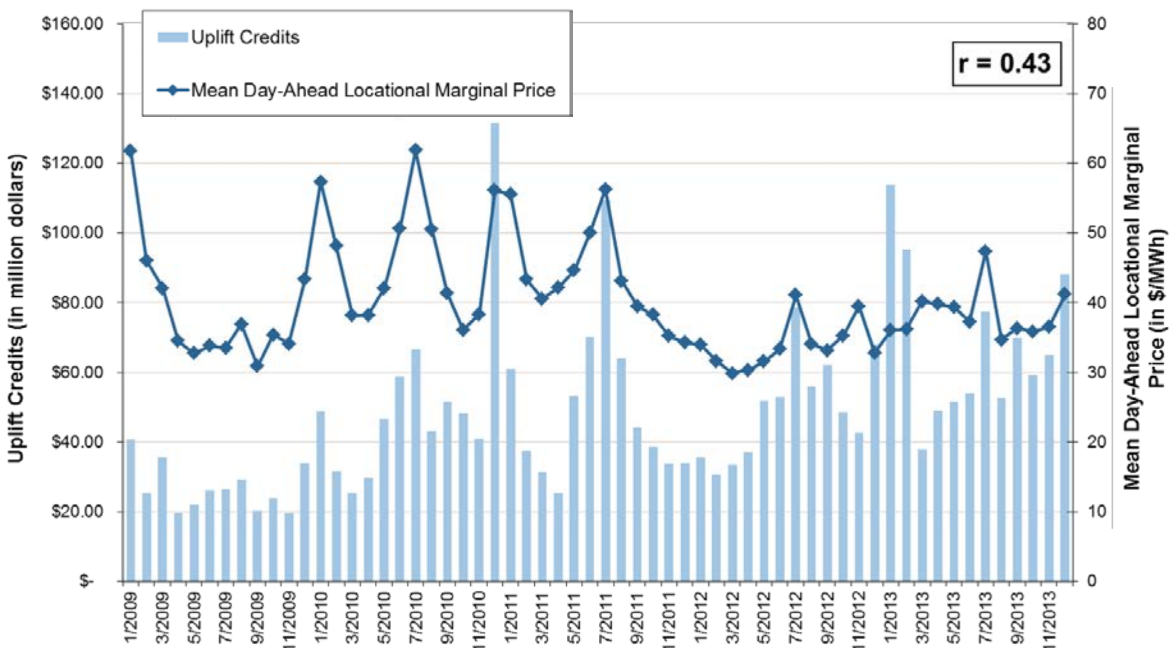
Notes: The day-ahead locational marginal prices are H.INTERNAL_HUB from Ventyx. The Pearson correlation coefficient (r) was used to assess correlation between monthly locational marginal price and monthly uplift credits. There were no reportable data for Q1 and Q2 2012.

Figure E.2: Uplift and LMP Correlation in NYISO



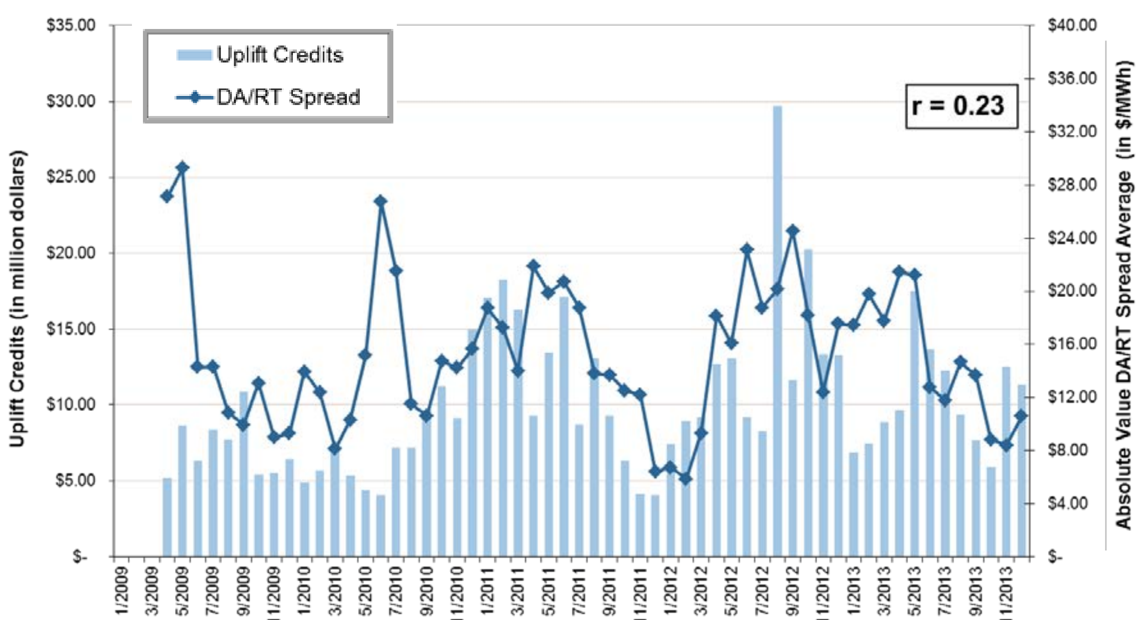
Notes: The day-ahead locational marginal prices are ZONE J from Ventyx. The Pearson correlation coefficient (r) was used to assess correlation between monthly locational marginal price and monthly uplift credits.

Figure E.3: Uplift and LMP Correlation in PJM



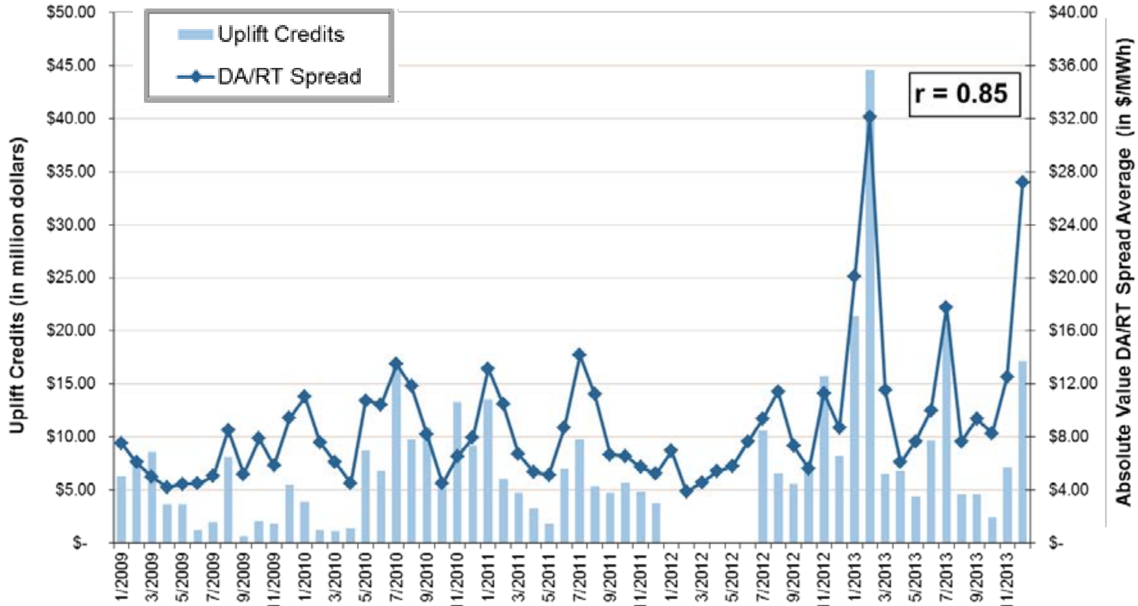
Notes: The day-ahead locational marginal prices are WESTERN HUB from Ventyx. The Pearson correlation coefficient (r) was used to assess correlation between monthly locational marginal price and monthly uplift credits.

Figure E.4: Uplift and DA/RT LMP Deviation in CAISO



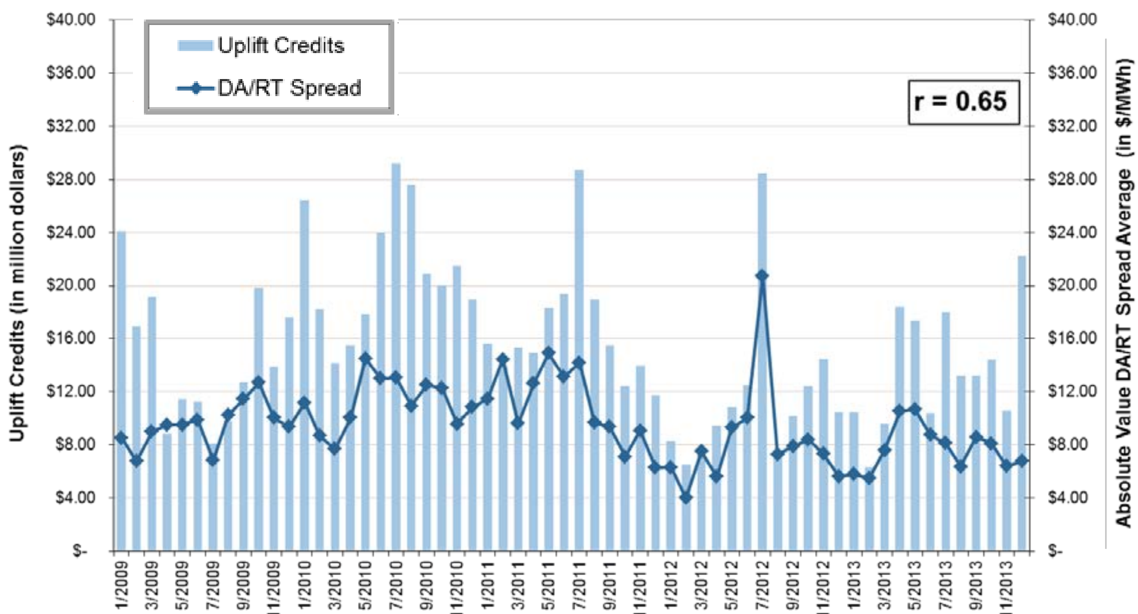
Notes: The day-ahead locational marginal prices are TH_SP15_GEN-APND from Ventyx. The DA/RT spread is the monthly average of the hourly, absolute value difference between the day-ahead and real-time locational marginal prices. The Pearson correlation coefficient (r) was used to assess correlation between monthly locational marginal price and monthly uplift credits.

Figure E.5: Uplift and DA/RT LMP Deviation in ISO-NE



Notes: The day-ahead locational marginal prices are H.INTERNAL_HUB from Ventyx. The DA/RT spread is the monthly average of the hourly, absolute value difference between the day-ahead and real-time locational marginal prices. The Pearson correlation coefficient (r) was used to assess correlation between monthly locational marginal price and monthly uplift credits. There were no reportable data for Q1 and Q2 2012.

Figure E.6: Uplift and DA/RT LMP Deviation in MISO



Notes: The day-ahead locational marginal prices are CINERGY.HUB from Ventyx. The DA/RT spread is the monthly average of the hourly, absolute value difference between the day-ahead and real-time locational marginal prices. The Pearson correlation coefficient (r) was used to assess correlation between monthly locational marginal price and monthly uplift credits.