California Independent System Operator Corporation

California ISO

Review of Real-Time Imbalance Energy Offset

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Table of Contents

Executive Summary

This paper reviews potential causes of real-time imbalance energy offset (RTIEO), with particular emphasis on the months following implementation of FERC Order 764. Our analysis suggests that recent large causes of RTIEO are unrelated to FERC Order 764 market changes. Furthermore, we estimate that most RTIEO in summer 2014 does not represent uplift that is ultimately paid by load serving entities.

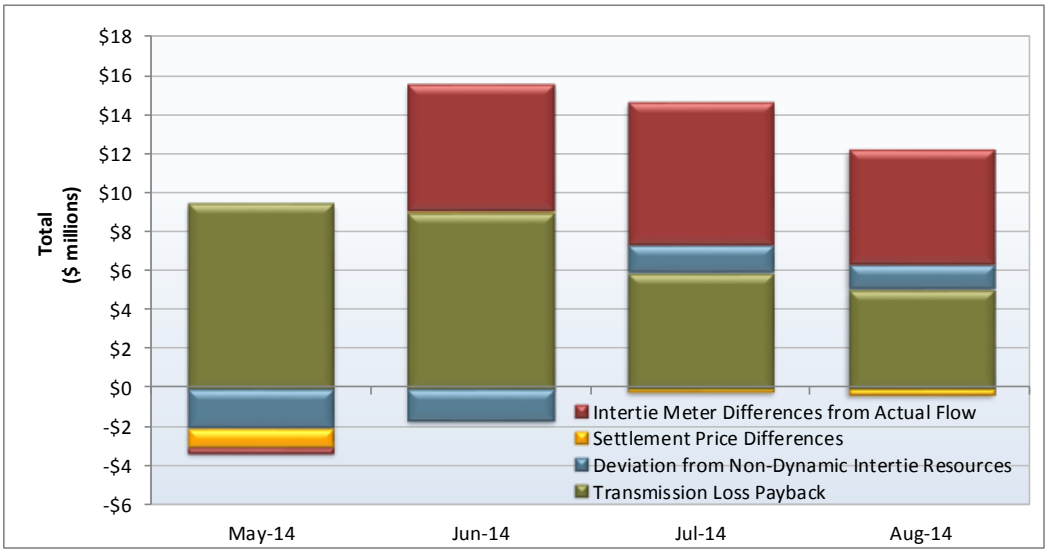
Between May and August 2014, transmission loss paybacks caused approximately $29 million of the $45 million of RTIEO over the period. However, most of this $29 million was previously paid as a credit to load. Therefore, its contribution to RTIEO does not represent uplift to load.

Approximately $19 million of RTIEO over this time period was caused by actual power flow exceeding the reported metered power flow into CAISO over a handful of interties. Similar to the transmission loss paybacks, this contribution to RTIEO does not represent uplift to load. This $19 million of RTIEO 'uplift' was previously paid as a credit to load through the unaccounted for energy settlement mechanism. The ISO has resolved the intertie metering issue that resulted in this portion of RTIEO and UFE. Revised settlements will reflect this change following the normal settlements timeline.

Other causes of RTIEO such as differences in settlement prices for metered generation and metered load were small. Overall, these other causes contributed to slight reductions in RTIEO charges.

The energy component of real-time revenue imbalance is an important indicator of potential inefficiencies in the overall market design. However, as was the case over the summer of 2014, RTIEO may not reflect the energy component of real-time revenue imbalance. In order to obtain an accurate representation of real-time revenue imbalance, other market settlements must be considered along with RTIEO.

Breakdown of major causes of RTIEO: May – August 2014



1 Introduction

The Department of Market Monitoring worked closely with the ISO to analyze potential causes of real-time imbalance energy offset (RTIEO) [1]. This analysis placed particular emphasis on the late spring and summer of 2014 following implementation of FERC Order 764. RTIEO is comprised of total market revenue imbalances and unaccounted for energy charges (payments) to load. RTIEO is distributed as a charge or credit to load and represents a portion of total real time imbalance offset charges[2]. This paper presents a decomposition of RTIEO into core theoretical components. This decomposition is used to frame illustrative examples of causes of RTIEO. We also provide quantitative estimates of contributing factors using the theoretical decomposition as a foundation. These quantitative estimates serve to provide an order of magnitude for factors that may warrant further investigation.

Market revenue imbalance results from two fundamental sources: the quantity of settled withdrawals differing from the quantity of settled injections, and the settlement prices of withdrawals differing from the settlement prices of injections. Differences in market settled quantities arise in real time markets due to differences in internal and external dispatch operating targets, transmission loss paybacks, and ramping of system resources. Additional differences in market settled quantities arise after the RTD optimization as a result of inadvertent interchange, as well as from differences in metering granularity for generation and load[3].

RTIEO does not reflect most revenue imbalances caused by differences between the quantity of settled injections and the quantity of settled withdrawals. This is because RTIEO is intended to reflect revenue imbalance that remains after an adjustment is made for unaccounted for energy (UFE). Despite the adjustment, some RTIEO continues to be caused by differences in market settled quantities. Moreover, unaccounted for energy can contribute directly to RTIEO when the unaccounted for quantity does not accurately reflect physical conditions.

Analysis from the period May 2014 – August 2014 suggests that the two dominant causes of RTIEO did not represent actual revenue imbalances uplifted to load. Transmission loss paybacks accounted for approximately $29 million of RTIEO over the period. The ISO previously credited most of this to load through a separate settlement process.[4] Therefore, its contribution to RTIEO does not represent uplift to load.

Approximately $19 million of additional RTIEO over this time period was caused by the physical power flow into CAISO exceeding the reported metered power flow into CAISO over a handful of interties. Similar to most of the transmission loss paybacks, this contribution to RTIEO does not represent uplift to load. This $19 million of RTIEO 'uplift' was previously paid as a credit to load through the unaccounted for energy settlement mechanism.

In the period following FERC Order 764 implementation, the contribution to RTIEO from sources other than the two large sources described above has been small. Deviations by non-dynamic intertie resources between scheduled and delivered quantities would create revenue imbalance and RTIEO; however, this cause was negligible over the period of consideration. Differences in settlement prices for metered generation and metered load

[1] This work would not have been possible without the contributions of ISO staff in Market Settlement Design and Configuration, Market Development and Analysis, and Market Settlement Validation and Resolution.

[2] Total real time imbalance offset costs are made up of RTIEO and real time congestion imbalance offset cost (RTCIO). RTIEO does not reflect revenue imbalance resulting from congestion costs.

[3] See Operating Procedure 2550 (http://www.caiso.com/Documents/2550.pdf) for additional detail on inadvertent interchange payback.

[4] Approximately $10 million of this amount was due to an accelerated transmission loss payback arrangement with Arizona Public Service (APS). This amount has not been credited to load and therefore represents uplift. This arrangement with APS is scheduled through April 2015. See http://www.caiso.com/Documents/AcceleratedTransmissionLossesReturn_ArizonaPublicService.htm for additional detail.

resulted in small credits to RTIEO. The contribution to RTIEO from hourly metering of load is largely offset by unaccounted for energy settlement.

The first large source of RTIEO identified by this analysis (transmission loss paybacks) could be addressed by an increased understanding of what RTIEO reflects or revisions to existing settlement rules. When a scheduling coordinator schedules an import that results in transmission loss repayments, the scheduling coordinator is charged transmission loss obligation charges. The collected amount is then allocated as a credit to load through a separate settlements process. Conducting this allocation through RTIEO has the potential to make a significant reduction to RTIEO and would result in RTIEO more accurately reflecting market revenue imbalance. To the extent that the current approach is needed or preferred, simply ensuring that RTIEO is interpreted correctly as not representing all sources of market charges and surpluses could help to provide a more accurate view of uplift.

The portion of RTIEO that originates from differences between reported metered intertie flows and actual physical intertie flows has been addressed by the ISO through the use of an alternate data source for the flows on the affected interties. Differences between the reported metered and actual intertie flows affect RTIEO only through the unaccounted for energy settlement mechanism. Because there is no other market settlement on this quantity, this cause does not represent a true market revenue imbalance. When reported metered flows are below actual intertie flows, measured demand receives a credit through the UFE mechanism, but this credit is recollected through RTIEO settlement. Revised settlements will reflect the ISO's resolution of this issue following the normal settlements timeline.

The energy component of real-time revenue imbalance is an important indicator of potential inefficiencies in the overall market design. However, as was the case over the summer of 2014, RTIEO may not reflect the energy component of real-time revenue imbalance. In order to obtain an accurate representation of real-time revenue imbalance, other market settlements must be considered along with RTIEO.

2 Decomposition of RTIEO

To better understand factors contributing to RTIEO, we decompose RTIEO into its core theoretical components. This decomposition serves to form a framework for analysis rather than to exactly replicate the settlements calculation of RTIEO. We begin with a basic definition for a given 5-minute interval. For all nodes $i \in \{I\}$, load resources $k \in \{K\}$, and internal generation, intertie resources, and virtual schedules $j \in \{J\}$:

$$RTIEO = -1 * [\sum_j [P^{FMM} * Q_j^{FMMSTL-DASTL}] + \sum_j [P^{RTD} * Q_j^{RTDSTL-FMMSTL}] + \sum_j [P^{RTD} * Q_j^{METERSTL-RTDSTL}] - \sum_k [P^{WA} * Q_k^{METERSTL-DASTL}] - \sum_i [P^{WA} * Q_i^{UFE}]] \quad (1)$$

Where:

- P^{FMM} and P^{RTD} are the system marginal energy component (SMEC) of locational marginal price (LMP) in the fifteen minute (FMM) and five minute (RTD) markets[5];
- P^{WA} is the hourly weighted average of FMM and RTD prices, weighted by load forecasts in each market. This is the price on which load and unaccounted for energy are settled;
- $Q_{j,k}^{MARKET2-MARKET1}$ is the difference in 1/12 of injection (>0) or withdrawal (<0) from resources *j,k* between *MARKET1* and *MARKET2*.

[5] RTIEO also reflects the loss component of LMP which is omitted from this simplified framework for purposes concept illustration. This should not significantly affect the relative magnitude of different causes of RTIEO.

- *MARKET1*, *MARKET2* ∈ {*DASTL*, *FMMSTL*, *RTDSTL*, *METERSTL*}
- Suffix '*STL*' indicates market settled quantities

- Q_i^{UFE} is the total settled quantity of unaccounted for energy at node *i* for which load has been charged (credited).

This basic definition implies that RTIEO can generally be thought of as revenue imbalance that remains after unaccounted for energy settlement is taken in to consideration. The value of RTIEO is interpreted from the market's point of view in which a revenue shortfall is a negative number. Note also that the definition of RTIEO does not consider the congestion component of LMP which is applicable only to real time congestion imbalance offset (RTCIO).

Equation (1) is expressed in terms of settlement quantities. Scheduled quantities of injections must balance scheduled quantities of withdrawals in both the FMM and RTD markets. However, the quantities used for settlement purposes may differ. Define the scheduled quantity in any market *MKT* as $Q^{MKTSCHED}$ and the settled quantity Q^{MKTSTL}. Then noting that $Q^{MKTSTL} = Q^{MKTSCHED} - (Q^{MKTSCHED} - Q^{MKTSTL})$ for any market, and assuming that day-ahead scheduled and settled quantities are equal, equation (1) can be rewritten as:

$$RTIEO =$$
$$-1 * [\sum_j P^{FMM} * Q_j^{FMMSCHED-DASCHED} + \sum_j P^{RTD} * Q_j^{RTDSCHED-FMMSCHED}$$
$$+ \sum_j P^{RTD} * Q_j^{METERSCHED-RTDSCHED} - \sum_k P^{WA} * Q_k^{METERSCHED-DASCHED}] \quad (2a)$$

$$-1 * [-\sum_j P^{FMM} * Q_j^{FMMSCHED-FMMSTL}] \quad (2b)$$

$$-1 * [-\sum_j P^{RTD} * (Q_j^{METERSCHED-METERSTL} - Q_j^{FMMSCHED-FMMSTL})] \quad (2c)[6]$$

$$+ \quad \sum_i P^{WA} * Q_i^{UFE} \quad (2d)$$

Expressing RTIEO as the sum of terms (2a) – (2d) provides three useful results for further analysis. Term (2a) defines revenue imbalance remaining when injections and withdrawals are equal in each market. This provides the foundation from which we can derive revenue imbalance resulting from differences in load and generation settlement prices. Terms (2b) and (2c) directly define revenue imbalance that results in the real time markets from differences in settled versus scheduled quantities of internal generation and net imports. This quantity based revenue imbalance can result from differences in internal and external dispatch operating targets, transmission loss paybacks, and ramping of static intertie schedules. Term (2d) illustrates the role of unaccounted for energy settlement in the calculation of RTIEO. Terms (2b) and (2c) can be used in their existing state in the formation of an analytical framework. Terms (2a) and (2d) are expanded to their useful form below.

The hourly weighted average price on which hourly metered load is settled, P^{WA}, is constructed using DLAP load forecasts for each market. Applying the definition of the load weighted price and the fact that FMM and RTD markets must balance, it can be shown that term (2a) can be expressed as[7]:

$$-1 * [\sum_j P^{RTD} * Q_j^{METERSCHED-RTDSCHED} - \sum_k P^{WA} * Q_k^{METERSCHED-RTDSCHED}] \quad (3)$$

[6] $Q_j^{METERSCHED}$ may differ from $Q_j^{METERSTL}$ for non-dynamic intertie resources since the settlements *METER* value in this context is the final tagged value. This can occur, for example, when exports are scheduled for transmission loss paybacks but are not settled as exports.

[7] When summed over all 12 RTD intervals in an hour, revenue imbalance from load and generation settlement price differences in the FMM and RTD markets sums to 0 when using the hourly load weighted average price to settle hourly metered load. Thus the net contribution of this source to RTIEO comes from uninstructed imbalance energy settled after the RTD market.

Equation (3) defines revenue imbalance when generation and load are settled on different prices and also captures quantity based revenue imbalances that occur after the RTD market is run. To separate these effects, we rewrite equation (3):

$$-1 * [\sum_j P^{RTD} * (\Delta Q_j^{INTGEN} + \Delta Q_j^{DYNGEN}) - \sum_k P^{WA} * (\Delta Q_k^{LOADMETER} - \Delta Q_k^{LOADACT} + \Delta Q_k^{LOADACT})] \quad (4)$$

Where:

- $\Delta Q_j^{INTGEN} + \Delta Q_j^{DYNGEN} = Q_j^{METERSCHED-RTDSCHED}$
  - *INTGEN*= internal generation, *DYNGEN*= dynamic intertie resource generation
- $\Delta Q_k^{LOADMETER} = Q_k^{METERSCHED-RTDSCHED}$
- $\Delta Q_k^{LOADACT} = Q_k^{ACTUALLOAD-RTDSCHED}$
  - *LOADACT*= actual load in 5-minute interval

Because the majority of load is metered hourly, $Q_k^{METERSCHED}$ in any 5-minute interval is an average quantity for the hour. The quantity of actual load in a 5-minute interval can be closely approximated since system injections and withdrawals must equal. Given this fact, $\sum_k \Delta Q_k^{LOADACT}$ can be well approximated as:

$$\sum_k \Delta Q_k^{LOADACT} \approx \sum_j (\Delta Q_j^{INTGEN} + \Delta Q_j^{DYNGEN} + \Delta Q_j^{NDSYSRES}) - \sum_j \Delta Q_j^{LOSSES} - \sum_j \varepsilon_j \quad (5)$$

The quantity $\Delta Q_j^{NDSYSRES}$ is the unscheduled deviation of non-dynamic intertie resources between RTD scheduled amounts and actual flowed amounts. Note that this quantity is settled only through unaccounted for energy settlement at an aggregate level. The term ε_j represents energy theft and other sources of unaccounted for energy not consumed by load.

Applying the approximation defined by term (5) to equation (4), adding and subtracting $\sum_j \Delta Q_j^{NDSYSRES}$, $\sum_j Q_j^{LOSSES}$, and $\sum_j \varepsilon_j$ and rearranging terms yields:

$$-1 * [\sum_j \left(\Delta Q_j^{INTGEN} + \Delta Q_j^{DYNGEN} + \Delta Q_j^{NDSYSRES} - \Delta Q_j^{LOSSES} - \varepsilon_j\right) * \left(P^{RTD} - P^{WA}\right) - \sum_j \Delta Q_j^{NDSYSRES} * P^{RTD}$$
$$+ \sum_j \Delta Q_j^{LOSSES} * P^{RTD} + \sum_j \varepsilon_j * P^{RTD} - \sum_k (\Delta Q_k^{LOADMETER} - \Delta Q_k^{LOADACT}) * P^{WA}] \quad (6)$$

Note that because $\sum_j Q_j^{LOSSES} \geq 0$ in any market, the quantity $\Delta Q_k^{LOADACT}$ represents an overlapping quantity of load and generation settled at different prices. This is the quantity of load imbalance between the RTD load forecast and actual load for the interval. Define this overlapping quantity of load and generation as $\Delta Q_k^{OVERLAP}$.

Then equation (6) can be finalized as[8]:

$$\sum_k \Delta Q_k^{OVERLAP} * \left(P^{WA} - P^{RTD}\right) \quad (7a)$$

$$+ \sum_j \Delta Q_j^{NDSYSRES} * P^{RTD} \quad (7b)$$

$$+ \sum_k (\Delta Q_k^{LOADMETER} - \Delta Q_k^{LOADACT}) * P^{WA} \quad (7c)$$

$$- \sum_j \varepsilon_j * P^{RTD} \quad (7d)$$

[8] The reflection of the loss component of LMP and inclusion of Real Time Marginal Losses Offset in the settlements calculation of RTIEO should offset loss related components. Because the loss component of LMP is excluded for simplification of this analysis, we also exclude any quantity of losses appearing explicitly in the formulation of RTIEO.

Term (7a) defines revenue imbalance that derives directly from settling generation and load on different prices. Term (7b) defines revenue imbalance that results from deviations of non-dynamic intertie schedules. Term (7c) defines revenue imbalance from hourly load metering. Term (7d) defines revenue imbalance from unaccounted for energy such as energy theft that is produced but not consumed by load. These four terms together (7a)-(7d) are the re-expression of Term (2a) that is most useful in our analytical framework.

Returning to Term (2d), note the settlements definition of unaccounted for energy as the sum of metered generation and metered net imports, less metered load and calculated losses. Unaccounted for energy is a calculation based on actual measured flows of energy. The real time market schedules must balance, but metered injections and withdrawals may not balance due to theft, metering granularity, or meter measurement error. This quantity is settled on the load-weighted average price, P^{WA}.

Because the RTD market must balance, and making explicit note of the possibility that intertie metered values could be different than actual flows, unaccounted for energy settlement can be expressed as:

$$[\sum_j(\Delta Q_j^{INTGEN} + \Delta Q_j^{DYNGEN} + \Delta Q_j^{NDSYSRES} - \Delta Q_j^{LOSSES}) - \sum_k \Delta Q_k^{LOADMETER}] * P^{WA} + \sum_j \delta_j * P^{WA} \quad (8a)$$

The summed terms $\Delta Q_j^{NDSYSRES} + \delta_j$ represent metered intertie flows, where δ_j represents differences from actual intertie flows. Intertie schedule deviations between final tagged and metered quantities are not settled outside of the unaccounted for energy settlement. Therefore, intertie metering differences from actual flow are only reflected in the calculation of unaccounted for energy and the quantity δ_j is not directly settled elsewhere. This justifies the explicit inclusion of this term in an expression of unaccounted for energy which highlights the contribution of this quantity to RTIEO.

Recalling the definition of $\sum_k \Delta Q_k^{LOADACT}$ set forth in equation (5) and applying to equation (8a), unaccounted for energy can be shown as:

$$\sum_k(\Delta Q_k^{LOADACT} - \Delta Q_k^{LOADMETER}) * P^{WA} + \sum_j \varepsilon_j * P^{WA} + \sum_j \delta_j * P^{WA} \quad (8b)$$

Combining terms (2b), (2c), (7a)-(7d), and (8b) yields an analytical framework for RTIEO:

$$\begin{aligned} RTIEO = & \\ & \sum_j P^{FMM} * Q_j^{FMMSCHED-FMMSTL} \\ + & \sum_j P^{RTD} * (Q_j^{METERSCHED-METERSTL} - Q_j^{FMMSCHED-FMMSTL}) \\ + & \sum_k \Delta Q_k^{OVERLAP} * (P^{WA} - P^{RTD}) \\ + & \sum_j \Delta Q_j^{NDSYSRES} * P^{RTD} \\ + & \sum_k(\Delta Q_k^{LOADMETER} - \Delta Q_k^{LOADACT}) * P^{WA} \\ - & \sum_k(\Delta Q_k^{LOADMETER} - \Delta Q_k^{LOADACT}) * P^{WA} \\ + & \sum_j \varepsilon_j * (P^{WA} - P^{RTD}) \\ + & \sum_j \delta_j * P^{WA} \end{aligned} \quad (9)$$

The framework in equation (9) is used to frame illustrative examples and form quantitative estimates of RTIEO. What may be of particular interest in the result of equation (9) is the way in which unaccounted for energy (UFE) ultimately enters RTIEO. The inclusion of UFE in the RTIEO calculation effectively allocates a credit or charge to measured demand. This is done to properly account for calculated revenue imbalance that has already been paid or charged to load for unaccounted for energy quantities. However, because intertie metering differences from actual flows are not accounted for elsewhere in market settlements, UFE quantities resulting from this source are not offsetting to any quantity creating a market revenue imbalance. This has the effect of increasing or decreasing RTIEO by the amount of this portion of UFE settlement. Additionally, some revenue imbalance remains since UFE and imbalance generation are settled on different prices. This effect is difficult to estimate directly. However, it is likely small in the absence of very extreme price differences.

3 Illustrative Examples

Equation (9) shows that RTIEO can derive from four primary sources. Equation (9) also shows that revenue imbalance from hourly load metering granularity is offset through unaccounted for energy settlement. Four primary sources from which RTIEO can arise are:

- Revenue imbalance in the FMM and RTD markets when scheduled and settled quantities differ;
- Revenue imbalance after the RTD market due to different settlement prices for metered load, UFE, and metered generation;
- Revenue imbalance resulting after the RTD market due to unscheduled deviations of static intertie schedules;
- Unaccounted for energy resulting from differences in metered and actual intertie flows

Transmission loss paybacks and differing internal and external dispatch operating targets (DOTs) provide examples of the first source of RTIEO. The next two sources are straightforward from their description. The final source is the result of a credit to load that is recollected through RTIEO settlement. The following examples illustrate scenarios where each of these sources result in RTIEO charges to load[9].

3.1 Transmission Loss Paybacks

Transmission loss paybacks result when a CAISO scheduling coordinator schedules an intertie transaction on a transmission line outside the CAISO BAA using CAISO transmission access[10]. Losses from the transaction incurred by the outside BAA are calculated and "repaid" as exports from the CAISO market. These exports are scheduled in the CAISO market and as such are backed by CAISO internal generation. Revenue imbalance arises when internal generation is incrementally dispatched and settled in the FMM and RTD markets to maintain power balance, but not offset by an export settlement. Although the repaid losses are billed to the appropriate CAISO scheduling coordinator, this amount is not reflected in the RTIEO calculation. Table 3.1a shows example market data for a 5-minute interval in which transmission loss paybacks result in RTIEO. In this example, the amount of generation settled in the FMM reflects both an increase in load and the increase in scheduled exports. However, settled

[9] All examples are intended as simple illustrations for a single 5-minute interval assuming 0 losses. For the load weighted average price, the calculation is based only in this interval. This is equivalent to an hourly weighted average price for an hour with identical FMM intervals and identical RTD intervals.

[10] One example of such lines is the Eldorado – Four Corners System within APS BAA. See OP 6930 (http://www.caiso.com/Documents/6930.pdf) for additional detail.

exports do not change. Table 3.1b shows the RTIEO calculation in the context of the base definition of equation (1) and the framework of equation (9).

Table 3.1a

Transmission Loss Payback

		Day- Ahead	FMM	RTD	Meter/Final Tag*	Actual Flows
Price	Gen (SMEC)	$35.00	$37.00	$38.00	$38.00	N/A
	Load (Weighted Avg)	$35.00	$37.50	$37.50	$37.50	N/A
Internal Generation	Scheduled MWh	2,500	2,505	2,506	2,506	2,506
	Settlement MWh	2,500	2,505	2,506	2,506	N/A
Dynamic Imports	Scheduled MWh	0	0	0	0	0
	Settlement MWh	0	0	0	0	N/A
Non-Dynamic Imports	Scheduled MWh	21	21	21	21	21
	Settlement MWh	21	21	21	21	N/A
Non-Dynamic Exports	Scheduled MWh	8	12	12	12	12
	Settlement MWh	8	8	8	8	N/A
Load	Scheduled MWh	2,513	2,514	2,515	2,515	2,515
	Settlement MWh	2,513	2,514	2,515	2,515	N/A
TOTAL Gen + Imports	Scheduled MWh	2,521	2,526	2,527	2,527	2,527
	Settlement MWh	2,521	2,526	2,527	2,527	
TOTAL Load + Exports	Scheduled MWh	2,521	2,526	2,527	2,527	2,527
	Settlement MWh	2,521	2,522	2,523	2,523	

*Quantity is metered value for for generation and load; final tagged value for non-dynamic intertie schedules.

Table 3.1b

Calculation of Revenue Imbalance

Market Settlement	Revenue Paid to Generators and Imports			Revenue Received from Load and Exports			Revenue Imbalance (Revenue Received - Revenue Paid)
	Quantity	Price	Revenue	Quantity	Price	Revenue	
FMM Generation & Intertie	5	$37.00	$185.00	0	$37.00	$0.00	-$185.00
RTD Generation & Intertie	1	$38.00	$38.00	0	$38.00	$0.00	-$38.00
Meter Generation	0	$38.00	$0.00	---	---	$0.00	$0.00
Meter Load	---	---	$0.00	2	$37.50	$75.00	$75.00
Total Revenue Imbalance	---	---	**$223.00**	---	---	**$75.00**	**-$148.00**

Equation(9)

	Quantity		Price		Amount
	-4	*	$37.00	=	-$148.00
+	0	*	$38.00	=	$0.00
+	0	*	-$0.50	=	$0.00
+	0	*	$38.00	=	$0.00
+	0	*	$37.50	=	$0.00
-	0	*	$37.50	=	$0.00
+	0	*	-$0.50	=	$0.00
+	0	*	$37.50	=	$0.00
RTIEO					**-$148.00**

Calculation of Unaccounted For Energy (UFE)

Category	Quantity	Price	Total
Metered Internal Generation	2,506	---	---
Metered Net Imports	9	---	---
Actual Net Imports	9	---	---
Intertie Meter Difference from Flow	0	---	---
Metered Load	2,515	---	---
Calculated Losses	0	---	---
Total UFE	**0**	**$37.50**	**$0.00**

Equation (1)

RTIEO= Revenue Imbalance + UFE	**-$148.00**

3.2 Differing Internal and External DOT in FMM

The internal dispatch operating target (DOT) refers to the dispatch used in the market optimization to accurately reflect imbalance conditions. The external DOT is the schedule on which a resource is dispatched and settled. These values may differ in the FMM and RTD markets as there may be operational reasons for reflecting a resource's actual output without settling or dispatching based on that output. This situation may apply to variable energy resources, for example, where dispatch and settlement are based on the resource's forecast but the market optimization must reflect actual output. Table 3.2a provides example market data while table 3.2b shows the RTIEO calculation.

Table 3.2a

Differing Internal/External DOT in FMM

		Day- Ahead	FMM	RTD	Meter/Final Tag*	Actual Flows
Price	Gen (SMEC)	$35.00	$37.00	$38.00	$38.00	N/A
	Load (Weighted Avg)	$35.00	$37.00	$37.00	$37.00	N/A
Internal Generation	Scheduled MWh	2,500	2,508	2,508	2,508	2,508
	Settlement MWh	2,500	2,506	2,506	2,508	N/A
Dynamic Imports	Scheduled MWh	0	0	0	0	0
	Settlement MWh	0	0	0	0	N/A
Non-Dynamic Imports	Scheduled MWh	21	21	21	21	21
	Settlement MWh	21	21	21	21	N/A
Non-Dynamic Exports	Scheduled MWh	8	8	8	8	8
	Settlement MWh	8	8	8	8	N/A
Load	Scheduled MWh	2,513	2,521	2,521	2,521	2,521
	Settlement MWh	2,513	2,521	2,521	2,521	N/A
TOTAL Gen + Imports	Scheduled MWh	2,521	2,529	2,529	2,529	2,529
	Settlement MWh	2,521	2,527	2,527	2,529	
TOTAL Load + Exports	Scheduled MWh	2,521	2,529	2,529	2,529	2,529
	Settlement MWh	2,521	2,529	2,529	2,529	

*Quantity is metered value for for generation and load; final tagged value for non-dynamic intertie schedules.

Table 3.2b

Calculation of Revenue Imbalance

Market Settlement	Revenue Paid to Generators and Imports			Revenue Received from Load and Exports			Revenue Imbalance (Revenue Received - Revenue Paid)
	Quantity	Price	Revenue	Quantity	Price	Revenue	
FMM Generation & Intertie	6	$37.00	$222.00	0	$37.00	$0.00	-$222.00
RTD Generation & Intertie	0	$38.00	$0.00	0	$38.00	$0.00	$0.00
Meter Generation	2	$38.00	$76.00	---	---	$0.00	-$76.00
Meter Load	---	---	$0.00	8	$37.00	$296.00	$296.00
Total Revenue Imbalance	**---**	**---**	**$298.00**	**---**	**---**	**$296.00**	**-$2.00**

Equation(9)

	Quantity		Price		Amount
	2	*	$37.00	=	$74.00
+	-2	*	$38.00	=	-$76.00
+	0	*	-$1.00	=	$0.00
+	0	*	$38.00	=	$0.00
+	0	*	$37.00	=	$0.00
-	0	*	$37.00	=	$0.00
+	0	*	-$1.00	=	$0.00
+	0	*	$37.00	=	$0.00
RTIEO					**-$2.00**

Calculation of Unaccounted For Energy (UFE)

Category	Quantity	Price	Total
Metered Internal Generation	2,508	---	---
Metered Net Imports	13	---	---
Actual Net Imports	13	---	---
Intertie Meter Difference from Flow	0	---	---
Metered Load	2,521	---	---
Calculated Losses	0	---	---
Total UFE	**0**	**$37.00**	**$0.00**

Equation (1)

RTIEO= Revenue Imbalance + UFE	**-$2.00**

3.3 Difference in Load and Generation Settlement Prices

Settlement of generation and load on different prices results in revenue imbalance that does not originate from settled quantity differences. Hourly metered load is settled on a weighted average price derived from load settlement forecasts for each market and interval across the relevant hour. Internal generation and intertie transactions are settled on the applicable market price. The settling of load on an hourly price weighted by FMM and RTD forecast prevents revenue imbalance in those markets when summed over the hour or when intervals are identical across the hour; however, revenue imbalance results from changes after the RTD market. Settlement of

an overlapping quantity of metered generation and actual load on these different prices results in revenue imbalance as the price weighting does not reflect load changes between the RTD forecast to actual load[11]. The data in Table 3.3a show a situation in which these settlement price differences are the only source of RTIEO. Table 3.3b provides additional detail of the RTIEO calculation for this example.

Table 3.3a

Difference in Load and Generation Settlement Prices

		Day- Ahead	FMM	RTD	Meter/Final Tag*	Actual Flows
Price	Gen (SMEC)	$35.00	$37.00	$38.00	$38.00	N/A
	Load (Weighted Avg)	$35.00	$37.20	$37.20	$37.20	N/A
Internal Generation	Scheduled MWh	2,500	2,508	2,510	2,514	2,514
	Settlement MWh	2,500	2,508	2,510	2,514	N/A
Dynamic Imports	Scheduled MWh	0	0	0	0	0
	Settlement MWh	0	0	0	0	N/A
Non-Dynamic Imports	Scheduled MWh	21	21	21	21	21
	Settlement MWh	21	21	21	21	N/A
Non-Dynamic Exports	Scheduled MWh	8	8	8	8	8
	Settlement MWh	8	8	8	8	N/A
Load	Scheduled MWh	2,513	2,521	2,523	2,527	2,527
	Settlement MWh	2,513	2,521	2,523	2,527	N/A
TOTAL Gen + Imports	Scheduled MWh	2,521	2,529	2,531	2,535	2,535
	Settlement MWh	2,521	2,529	2,531	2,535	
TOTAL Load + Exports	Scheduled MWh	2,521	2,529	2,531	2,535	2,535
	Settlement MWh	2,521	2,529	2,531	2,535	

*Quantity is metered value for for generation and load; final tagged value for non-dynamic intertie schedules.

Table 3.3b

Calculation of Revenue Imbalance

Market Settlement	Revenue Paid to Generators and Imports			Revenue Received from Load and Exports			Revenue Imbalance (Revenue Received - Revenue Paid)
	Quantity	Price	Revenue	Quantity	Price	Revenue	
FMM Generation & Intertie	8	$37.00	$296.00	0	$37.00	$0.00	-$296.00
RTD Generation & Intertie	2	$38.00	$76.00	0	$38.00	$0.00	-$76.00
Meter Generation	4	$38.00	$152.00	---	---	$0.00	-$152.00
Meter Load	---	---	$0.00	14	$37.20	$520.80	$520.80
Total Revenue Imbalance	**---**	**---**	**$524.00**	**---**	**---**	**$520.80**	**-$3.20**

Equation(9)

	Quantity		Price		Amount
	0	*	$37.00	=	$0.00
+	0	*	$38.00	=	$0.00
+	4	*	-$0.80	=	-$3.20
+	0	*	$38.00	=	$0.00
+	0	*	$37.20	=	$0.00
-	0	*	$37.20	=	$0.00
+	0	*	-$0.80	=	$0.00
+	0	*	$37.20	=	$0.00
RTIEO					**-$3.20**

Calculation of Unaccounted For Energy (UFE)

Category	Quantity	Price	Total
Metered Internal Generation	2,514	---	---
Metered Net Imports	13	---	---
Actual Net Imports	13	---	---
Intertie Meter Difference from Flow	0	---	---
Metered Load	2,527	---	---
Calculated Losses	0	---	---
Total UFE	**0**	**$37.20**	**$0.00**

Equation (1)

RTIEO= Revenue Imbalance + UFE	**-$3.20**

3.4 Deviation from Schedules of Static Intertie Resources

Metered output for a non-dynamic intertie resource is assumed to match the resource's RTD schedule and final tagged value. In the event that a non-dynamic intertie resource delivers a quantity less than its RTD schedule and

[11] Overlapping quantity should equal the value of actual load in the interval. See explanation following equation (6).

final tagged value, internal generation must cover the shortfall to maintain system balance. Similarly, in an over-generation situation, settled internal generation will support surplus exports. The incremental internal generation is settled based on final metered output; however, the downward deviation of the intertie import or surplus intertie export is not directly settled. Revenue imbalance and therefore RTIEO results from the additional payments to internal generators that are not offset by settlement of the intertie resource deviation. This scenario is displayed in Table 3.4a where load is unchanged after the RTD market, but metered internal generation increases. The detailed RTIEO calculation is in Table 3.4b.

Table 3.4a

Deviation of Scheduled Static Intertie Resources

		Day- Ahead	FMM	RTD	Meter/Final Tag*	Actual Flows
Price	Gen (SMEC)	$35.00	$37.00	$38.00	$38.00	N/A
	Load (Weighted Avg)	$35.00	$37.20	$37.20	$37.20	N/A
Internal Generation	Scheduled MWh	2,500	2,508	2,510	2,514	2,514
	Settlement MWh	2,500	2,508	2,510	2,514	N/A
Dynamic Imports	Scheduled MWh	0	0	0	0	0
	Settlement MWh	0	0	0	0	N/A
Non-Dynamic Imports	Scheduled MWh	21	21	21	21	17
	Settlement MWh	21	21	21	21	N/A
Non-Dynamic Exports	Scheduled MWh	8	8	8	8	8
	Settlement MWh	8	8	8	8	N/A
Load	Scheduled MWh	2,513	2,521	2,523	2,523	2,523
	Settlement MWh	2,513	2,521	2,523	2,523	N/A
TOTAL Gen + Imports	Scheduled MWh	2,521	2,529	2,531	2,535	2,531
	Settlement MWh	2,521	2,529	2,531	2,535	
TOTAL Load + Exports	Scheduled MWh	2,521	2,529	2,531	2,531	2,531
	Settlement MWh	2,521	2,529	2,531	2,531	

*Quantity is metered value for for generation and load; final tagged value for non-dynamic intertie schedules.

Table 3.4b

Calculation of Revenue Imbalance

Market Settlement	Revenue Paid to Generators and Imports			Revenue Received from Load and Exports			Revenue Imbalance (Revenue Received - Revenue Paid)
	Quantity	Price	Revenue	Quantity	Price	Revenue	
FMM Generation & Intertie	8	$37.00	$296.00	0	$37.00	$0.00	-$296.00
RTD Generation & Intertie	2	$38.00	$76.00	0	$38.00	$0.00	-$76.00
Meter Generation	4	$38.00	$152.00	---	---	$0.00	-$152.00
Meter Load	---	---	$0.00	10	$37.20	$372.00	$372.00
Total Revenue Imbalance	**---**	**---**	**$524.00**	**---**	**---**	**$372.00**	**-$152.00**

Equation(9)

	Quantity		Price		Amount
	0	*	$37.00	=	$0.00
+	0	*	$38.00	=	$0.00
+	0	*	-$0.80	=	$0.00
+	-4	*	$38.00	=	-$152.00
+	0	*	$37.20	=	$0.00
-	0	*	$37.20	=	$0.00
+	0	*	-$0.80	=	$0.00
+	0	*	$37.20	=	$0.00
RTIEO					**-$152.00**

Calculation of Unaccounted For Energy (UFE)

Category	Quantity	Price	Total
Metered Internal Generation	2,514	---	---
Metered Net Imports	9	---	---
Actual Net Imports	9	---	---
Intertie Meter Difference from Flow	0	---	---
Metered Load	2,523	---	---
Calculated Losses	0	---	---
Total UFE	**0**	**$37.20**	**$0.00**

Equation (1)

RTIEO= Revenue Imbalance + UFE	**-$152.00**

3.5 The Role of UFE in RTIEO Calculation

The final example presented in Tables 3.5a and 3.5b illustrates the offset of revenue imbalance from hourly load metering by unaccounted for energy (UFE) settlement. This is intended to provide one example of the way in

which UFE inclusion in RTIEO accounts for revenue imbalance already paid or charged to load. In this example, market revenue shortfall results from load metering on an hourly basis. The quantity appears in unaccounted for energy and is billed to load accordingly. The calculation of RTIEO then reflects the fact that load has already paid to cover this amount of revenue imbalance. This example also illustrates the way in which underreported intertie net imports affect RTIEO through UFE.

Unaccounted for energy is calculated by the definition preceding equation (8a), with explicit inclusion of a term to capture intertie metering differences from flow. As discussed earlier in this document, actual load in a 5-minute interval is well approximated as the sum of metered generation and net imports less transmission losses and UFE not reflected in the estimate of actual load (e.g., theft). These other sources are assumed to be zero in this example. In the example presented in Table 3.5a, load settlement reflects a decrease between RTD and metered quantities but the amount reflecting actual load is recaptured in unaccounted for energy settlement. The role of UFE in RTIEO is illustrated in Table 3.5b. This table shows the offset of revenue imbalance from load metering granularity as well as UFE settlement of 4 MWh of unmeasured intertie flows.

Table 3.5a

The Effect of Unaccounted For Energy Settlement

		Day- Ahead	FMM	RTD	Meter/Final Tag*	Actual Flows
Price	Gen (SMEC)	$35.00	$37.00	$38.00	$38.00	N/A
	Load (Weighted Avg)	$35.00	$37.20	$37.20	$37.20	N/A
Internal Generation	Scheduled MWh	2,500	2,508	2,510	2,510	2,510
	Settlement MWh	2,500	2,508	2,510	2,510	N/A
Dynamic Imports	Scheduled MWh	0	0	0	0	0
	Settlement MWh	0	0	0	0	N/A
Non-Dynamic Imports	Scheduled MWh	21	21	21	21	21
	Settlement MWh	21	21	21	21	N/A
Non-Dynamic Exports	Scheduled MWh	8	8	8	8	8
	Settlement MWh	8	8	8	8	N/A
Load	Scheduled MWh	2,513	2,521	2,523	2,517	2,523
	Settlement MWh	2,513	2,521	2,523	2,517	N/A
TOTAL Gen + Imports	Scheduled MWh	2,521	2,529	2,531	2,531	2,531
	Settlement MWh	2,521	2,529	2,531	2,531	
TOTAL Load + Exports	Scheduled MWh	2,521	2,529	2,531	2,525	2,531
	Settlement MWh	2,521	2,529	2,531	2,525	

*Quantity is metered value for for generation and load; final tagged value for non-dynamic intertie schedules.

Table 3.5b

Calculation of Revenue Imbalance

Market Settlement	Revenue Paid to Generators and Imports			Revenue Received from Load and Exports			Revenue Imbalance (Revenue Received - Revenue Paid)
	Quantity	Price	Revenue	Quantity	Price	Revenue	
FMM Generation & Intertie	8	$37.00	$296.00	0	$37.00	$0.00	-$296.00
RTD Generation & Intertie	2	$38.00	$76.00	0	$38.00	$0.00	-$76.00
Meter Generation	0	$38.00	$0.00	---	---	$0.00	$0.00
Meter Load	---	---	$0.00	4	$37.20	$148.80	$148.80
Total Revenue Imbalance	**---**	**---**	**$372.00**	**---**	**---**	**$148.80**	**-$223.20**

Equation(9)

	Quantity		Price		Amount
	0	*	$37.00	=	$0.00
+	0	*	$38.00	=	$0.00
+	0	*	-$0.80	=	$0.00
+	0	*	$38.00	=	$0.00
+	-6	*	$37.20	=	-$223.20
-	-6	*	$37.20	=	$223.20
+	0	*	-$0.80	=	$0.00
+	-4	*	$37.20	=	-$148.80
RTIEO					**-$148.80**

Calculation of Unaccounted For Energy (UFE)

Category	Quantity	Price	Total
Metered Internal Generation	2,510	---	---
Metered Net Imports	9	---	---
Actual Net Imports	13	---	---
Intertie Meter Difference from Flow	-4	---	---
Metered Load	2,517	---	---
Calculated Losses	0	---	---
Total UFE	**2**	**$37.20**	**$74.40**

Equation (1)

RTIEO= Revenue Imbalance + UFE	**-$148.80**

4 Quantitative Estimates

The framework of equation (9) was used to conduct an analysis of the potential causes of RTIEO over the period May – August 2014. Over this period, causes related to intertie transactions appear to have contributed significantly to RTIEO, although much of the RTIEO from this time is settled elsewhere and does not represent true uplift to load. Revenue imbalance from transmission loss paybacks contributed an average of approximately $7.25 million per month or about $29 million for the period. Metered intertie flows below reported actual flows contributed approximately $19 million for the period. The total impact of deviation by static intertie schedules was negligible over the period. Differences in settlement prices for metered generation and metered load resulted in a credit to RTIEO. Figure 1 below shows the estimated breakout of RTIEO by major cause and month over the analyzed period. This figure shows that when transmission loss payback and intertie metering differences are removed, remaining RTIEO is quite small in the months following FERC Order 764. Figure 2 shows a comparison of the overall RTIEO estimate to the settled value for the period May – August 2014.

Figure 1: Breakdown of major causes of RTIEO: May – August 2014

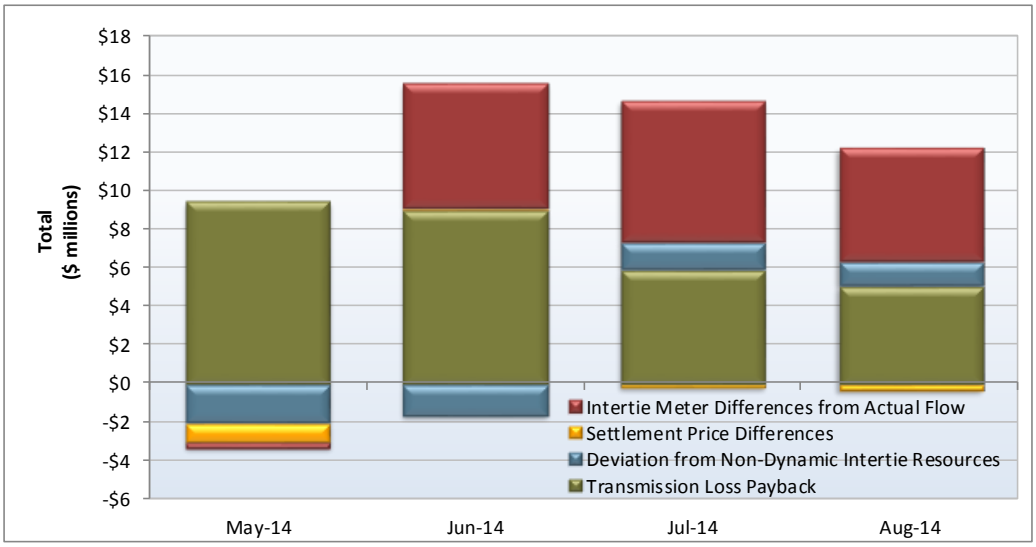
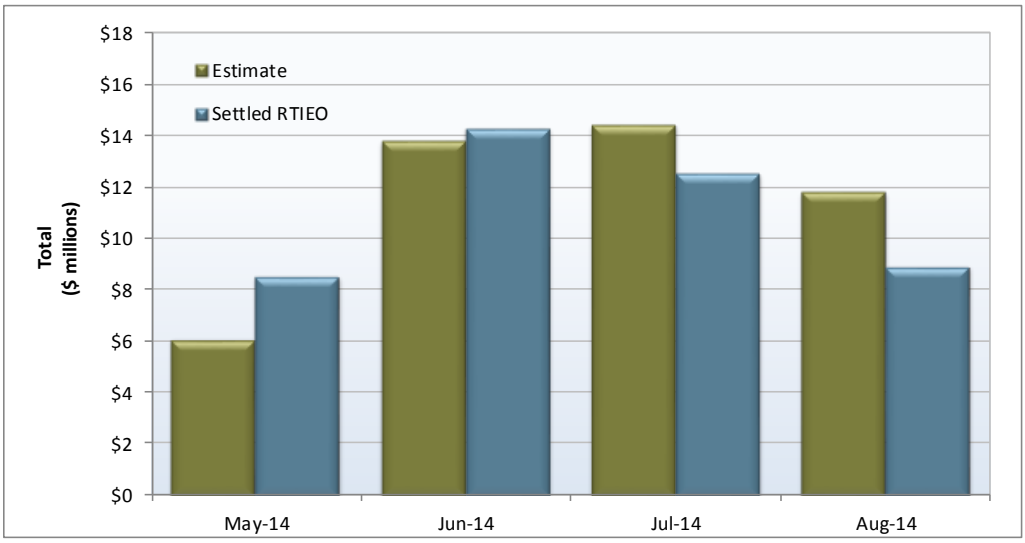


Figure 2: Analysis estimate versus settled RTIEO: May – August 2014[12]



This analysis identifies a couple of potentially large sources of RTIEO and provides an order of magnitude for factors that may warrant further investigation. When reviewing such estimates it is important to keep a couple of points in mind and to interpret the estimates in the proper context. First, note that RTIEO is a metric of total revenue imbalance. As such, the nature of the calculation is that some causes increase the imbalance while others decrease the imbalance. For this reason, it may be misleading to express any one number as a percentage of RTIEO and thus we present only dollar amounts. Second, recall from equation (9) that unaccounted for energy from sources not reflected in an estimate of load can contribute to RTIEO. Because this amount is not observable and difficult to estimate, it is not reflected in our quantitative estimates. Finally, this analysis estimates revenue imbalance from transmission loss paybacks directly and does not consider other potential sources of revenue imbalance such as differing internal and external dispatch operating targets. Earlier analysis suggests that the relative contribution of these factors to RTIEO is likely small.

5 Further Discussion

Results of this analysis suggest that transmission loss paybacks and metered net imports below actual physical imports were likely the key contributors to RTIEO from May 2014 – August 2014. Although this analysis focuses on the time period after FERC Order 764 was implemented, it is noteworthy that these causes are not new as a result of FERC Order 764. Neither of these causes represents a true market revenue imbalance, and each could be addressed by revision to existing settlement rules or simply better understanding the definition of RTIEO.

As discussed in Section 3.1, one way RTIEO arises is from revenue imbalance when internal generation is incrementally dispatched and settled in the FMM and RTD markets to maintain power balance, but not offset by an export settlement. Repaid losses are charged to the appropriate scheduling coordinator as transmission loss obligation charges, and these collected transmission loss obligation charges are then paid as a credit to load. This separate allocation is not reflected in the RTIEO calculation. Because of this, RTIEO overstates the true market

[12] Consistent with settlements practice over much of this period, estimates of RTIEO in this analysis are constructed using the hourly average RTD price for UFE and load settlement. Revisions to settlements that incorporate the load weighted average price may result in future changes to estimated and settled values.

revenue imbalance. Revising the settlements configuration to allocate transmission loss obligation charges in the calculation of RTIEO would reduce RTIEO and would more accurately reflect market revenue imbalance; however, some differences exist between the current allocation of transmission loss obligation charges and that of RTIEO. To the extent that the current approach is needed or preferred, simply ensuring that the RTIEO calculation is well understood as not reflecting all elements of revenue imbalance could help to provide a more accurate view of uplift. For example, with the knowledge that approximately $19 million of transmission loss obligation charges were allocated to measured demand from May – August 2014, one can subtract this amount from RTIEO to get a better idea of the true remaining uplift. To the extent that there are other such allocations related to other causes of RTIEO, those too could be deducted to improve the measure of uplift. While this approach would make significant improvements to the understanding of RTIEO and actual uplift, some revenue imbalance may remain due to differences in settlement prices at which transmission losses were incurred and repaid.

This analysis also finds that metered net intertie imports below actual physical flows have the potential to make a substantial contribution to RTIEO. As discussed above, the contribution to RTIEO enters through unaccounted for energy. Because there is no market settled quantity for this difference, the amount remains in RTIEO. This amount does not represent a true market revenue imbalance and is simply a recollection of the amount paid to load through UFE settlement. The ISO has resolved the intertie metering issue that resulted in this portion of RTIEO through the use of alternative data sources to report flows over the affected interties. Revised settlements will reflect this change following the standard settlements timeline. Addressing this issue will result in a value of RTIEO that more accurately reflects market revenue imbalance.