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Market Operations Inadvertent Interchange White Paper

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1. Introduction

This white paper details the various options available for handling Inadvertent in the MISO Market. MISO has presented these options and recommendations at the MIWG and received positive feedback from the Stakeholder community so efforts have been taken to develop the necessary infrastructure. This infrastructure includes development of the necessary automated tools and modifications to existing tools and drafting and submittal of several NERC Waivers.

Inadvertent interchange arises when the metered net actual interchange (NAI) of a Control Area (CA) differs from the net scheduled interchange (NSI). Although the implementation of the MISO energy markets will weaken the economic reasons for collecting and reporting interchange between participating CA's the inadvertent interchange between MISO and the other participants in the eastern interconnection must be managed. In addition there are regulatory requirements and settlement implications to be considered.

The issues considered in this white paper can be divided into three areas. The first set of issues concerns the recording, reporting, and payback of inadvertent energy. The second set of issues relates to the effect on market settlement. The third set of issues relates to the management of pre-market inadvertent accounts once the market begins.This paper establishes a simple model of a multiple control area MISO system to develop some example data that is then used to assist in explaining the issues and options for addressing them.

2. Managing Inadvertent Energy

Currently inadvertent energy accounts are maintained by each control area and are reported monthly to the appropriate Regional Reliability Council (Region) and then to NERC.. Control areas can pay back inadvertent interchange unilaterally by under or over generating (depending on over or under status of account) with some restrictions. It is also possible to trade off under and over accounts between control areas, although this option is not commonly used. Inadvertent is managed in two independent blocks, On Peak and Off Peak, depending on the day and hour the inadvertent was incurred. Payback of On Peak inadvertent must be repaid in an On Peak period. The options and alternatives discussed in this paper implicitly include the distinction between On Peak and Off Peak inadvertent.

2.1. Inadvertent Energy Accounting Options

The sections following list options for managing inadvertent energy accounts under the MISO market.

2.1.1. Energy Accounting Option 1 – Maintain each CA inadvertent account separately

This option is the most similar to current practices being performed today - each Control Area calculates and reports their own inadvertent energy to their Region. These values must agree with the data produced by the MISO settlement process. The inadvertent energy for each Control Area within MISO is calculated, and sums to the MISO inadvertent energy total. This option maintains the current practice of an inadvertent account for each CA within MISO.

Payback would occur as it does currently. On Peak and Off Peak energy is separately tracked and paid back under the requirements of NERC Policy 1.

Example of Inadvertent Energy Accounting:

Hour	A MW	B MW	MISO
1	-0.59	2.59	2
2	11.32	-8.32	3
3	3.67	-5.67	-2

Advantages: Maintains current practices and conforms to NERC requirements for CA reporting.

Disadvantages: Requires individual accounting of CA inadvertent energy and may complicate MISO payback procedures. Control Areas would be maintaining inadvertent accounts for energy that had been financially settled so it's possible a Control Area would be "double dipped" – they would have to pay for inadvertent energy they were short and also pay it back to the interconnection

Consistent with this accounting option there are two alternatives for payback:

Energy Payback Alternative 1 – Self Management

In this alternative each CA is responsible for performing bilateral or unilateral payback, in the same way as current arrangements operate.

Advantages: Consistent with current practice and this is a simpler implementation with no need for MISO to calculate and implement correction signals.

Disadvantages: Will not necessarily balance MISO accounts reliably over time and there are limited incentives for individual CA accounts to be brought into balance.

Energy Payback Alternative 2 – Individual CA Controlled (MISO input)

MISO controls unilateral payback by modifying the CA NSI signals. Each CA's NSI instruction would be increased or decreased by a small amount, depending on the inadvertent account status for MISO. The pre-adjustment NSI signal is used in calculating actual interchange.

Advantages: Ensures that MISO inadvertent account is balanced over time.

Disadvantages: Will not necessarily balance individual account reliably over time and there are limited incentives for individual CA's to follow these instructions.

2.1.2. Energy Accounting Option 2 – Offset to Net CA

The inadvertent energy for each Control Area within MISO is calculated, and sums to the MISO inadvertent energy total. The individual CA inadvertent totals are netted against each other hourly to lower the incurred inadvertent, but not change the MISO total. This is equivalent to distributing the MISO inadvertent total to those control areas that have inadvertent in the same direction as MISO.

Example of Adjusted Inadvertent Energy:

Hour	A MW	B MW	MISO
1	0	2	2
2	3	0	3
3	0	-2	-2

Advantages: Close to current practices and conforms to NERC requirements and waivers for CA reporting but probably does not meet the intent of NERC Policy 3.

Disadvantages: Requires individual accounting of CA inadvertent energy and may mask under performing CA's. Control Areas would be maintaining inadvertent accounts for energy that had been financially settled so it's possible a Control Area would be "double dipped" – they would have to pay for inadvertent energy they were short and also pay it back to the interconnection

Consistent with this accounting option there are two alternatives for payback (these options are the same as for Option 1):

Energy Payback Alternative 1 – Self Management

Each CA is responsible for performing bilateral or unilateral payback, in the same way as current arrangements operate.

Advantages: Consistent with current practice and this is a simpler implementation with no need for MISO to calculate and implement correction signals.

Disadvantages: Will not necessarily balance MISO's account reliably over time and there are limited incentives for individual CA accounts to be brought into balance.

Energy Payback Alternative 2 – Individual CA Controlled (MISO input)

In this alternative MISO controls unilateral payback by modifying the real time NSI signals sent to each CA. The NSI instruction is increased or decreased depending on the inadvertent account status for MISO. The pre-adjustment NSI signal is used in calculating actual interchange so that the payback process corrects the CA account.

Advantages: Ensures that MISO inadvertent account is balanced over time.

Disadvantages: Will not necessarily balance individual account reliably over time and there are limited incentives for individual CA's to follow these instructions.

2.1.3. Energy Accounting Option 3 – Assign to a single ("Bank") CA

The inadvertent energy for each Control Area within MISO is calculated, and sums to the MISO inadvertent energy total. This option assigns the MISO total to a single (willing) CA to act as a "bank" or agent for MISO. Inadvertent for all other CA's is set to zero.

This would be done by special schedules (called Inadvertent Consolidation Schedules) that would not be included in the settlement process. These special schedules would effectively move the inadvertent from each Control Area to the Bank Control Area each month. Two schedules per Control Area would be needed: one for On Peak and one for Off Peak.

All Control Areas would report Scheduled and Actual Interchange to the Regions as they do now; the only difference being the Scheduled and Actual Interchange would equal for all MISO Control Areas (and the resulting inadvertent would be zero for these Control Areas) except the Bank.

Example of Assigned Inadvertent Energy:

Hour	A MW	B MW	MISO
1	2	0	2
2	3	0	3
3	-2	0	-2

Advantages: Simplifies CA accounting and inadvertent payback procedures

Disadvantages: Inconsistent with NERC requirements on CA's to pay back inadvertent (although CA inadvertent can still be reported) and masks performance of individual CA's on ongoing basis. MISO would also need to find a Control Area willing to become the "Bank".

Consistent with this accounting option there are two alternatives for payback:

Energy Payback Alternative 3 – Single CA Controlled (MISO Input)

In this alternative MISO performs unilateral payback by modifying the "bank" CA NSI signal. The "bank" CA's NSI instruction is increased or decreased depending on the MISO /CA inadvertent account status. The pre-adjustment NSI signal is used for settlements while the MISO adjustments that are excluded from settlements would result in managing the inadvertent account balance.

Advantages: Ensures that the MISO account is moving in the correct direction

Disadvantages: Incompatible with individual control area accounting because inadvertent payback cannot be attributed on a CA basis

Energy Payback Option 4 – MISO Special Schedule

In this alternative, unilateral payback is performed by implementing a special inadvertent physical schedule. This would be dispatched as a normal schedule, but the quantity involved would be removed from the calculation of MISO NSI after-the-fact. Also no financial settlement would occur on this schedule.

Advantages: Ensures that MISO account is moving in the correct direction
Payback of inadvertent is based on market bids and offers

Disadvantages: Incompatible with individual control area accounting because inadvertent payback cannot be attributed on a CA basis

2.1.4. Energy Accounting Option 4 – Assign to MISO

In this option, all inadvertent for MISO is assigned to MISO. This option assumes that MISO will be allowed to calculate and maintain an Inadvertent Account, which requires a NERC approved waiver. Individual MISO Control Areas would not need to calculate or report inadvertent.

Again, Inadvertent Consolidation Schedules as described in Option 3 would accomplish this.

Example of Assigned Inadvertent Energy:

Hour	A MW	B MW	MISO
1	0	0	2
2	0	0	3
3	0	0	-2

Advantages: Simplifies CA accounting and inadvertent payback procedures

Disadvantages: Inconsistent with NERC requirements on CA's to calculate, track and report inadvertent since MISO is the holder of the inadvertent account. This option could mask underperformance of individual CA's on an ongoing basis.

Consistent with this accounting option there are two alternatives for payback:

Energy Payback Alternative 2 – Individual CA Controlled (MISO input)

In this alternative MISO controls unilateral payback by modifying the real time NSI signals sent to each CA. The NSI instruction is increased or decreased depending on the inadvertent account status for MISO. The pre-adjustment NSI signal is used in calculating actual interchange so that the payback process corrects the MISO inadvertent account.

Advantages: Ensures that MISO inadvertent account is balanced over time.

Disadvantages: There are limited incentives for individual CA's to follow these instructions.

Energy Payback Option 4 – MISO Special Schedule

In this alternative unilateral payback is performed by implementing a special MISO Inadvertent Repayment Physical schedule. This would be dispatched as a normal schedule, but the quantity involved would be removed from the calculation of MISO NSI. Also no financial settlement would occur on this schedule.

Advantages: Ensures that MISO account is moving in the correct direction
Payback of inadvertent is based on market bids and offers

Disadvantages: Incompatible with individual control area accounting because inadvertent payback cannot be attributed on a CA basis.

2.1.5. Recommendation

The preferred solution for inadvertent energy accounting is Energy Accounting Option 4 – Assign to MISO. In the MISO market, generation is paid for all production and load is charged for all consumption. Adding obligations for payback of inadvertent energy is inconsistent with this market settlement. Managing inadvertent energy on a MISO wide basis preserves the benefits and obligations with the Eastern Interconnection while removing the obligations between control areas within MISO. Option 4 requires a NERC waiver. Option 3 is the next most desirable alternative if a NERC waiver is not available.

The recommended solution for inadvertent energy payback is Energy Payback Option 4 – MISO Special Schedule.

3. Managing Net Settlement Totals

Current practice does not result in a calculated revenue shortage or surplus associated with inadvertent energy. Moving to a market framework changes this. A financial surplus or shortage will arise from any inadvertent interchange in each hour as illustrated in the example above.

3.1. Calculation of Inadvertent Revenue

The example in Appendix Ashows how shortages or surpluses arise. The calculation of the amount is complicated by the inclusion of losses and constraints in the market pricing. The total market surplus or shortage is not solely due to inadvertent energy and it is impractical to separately determine each component that contributes to the surplus. It is also impossible to assign inadvertent energy to particular external

transactions[1]. Therefore a method of assigning a price to the inadvertent energy total is required. There are two options listed below.

3.1.1. Inadvertent Energy Price Option 1 – Control Area Basis

This option calculates the inadvertent revenue surplus or loss on a CA basis. The hourly LMP for each generator Pnode in the CA control area is averaged resulting in an hourly per MWh generation price for the CA. This is multiplied by the hourly inadvertent energy for the CA resulting in inadvertent revenue for the CA. The inadvertent revenue for each CA sums to the MISO total inadvertent revenue.

Hour	Gen Price A	Gen Price B	Inadv A Revenue	Inadv B Revenue	MISO Inadv Revenue
1	$12.97	$12.59	-$7.68	$32.64	-$24.96
2	$14.19	$14.18	$160.60	-$117.93	-$42.66
3	$12.85	$12.68	$47.12	-$71.83	$24.72

Advantages: Fairly accurate representation of the value of inadvertent.

Disadvantages: Rather complex.

3.1.2. Inadvertent Energy Price Option 2 – MISO basis

This option calculates the inadvertent revenue or surplus on a MISO basis. The hourly LMP for each generator Pnode in MISO is averaged resulting in a per MWh generation price for MISO. This is multiplied by the hourly inadvertent energy for MISO resulting in inadvertent revenue for MISO.

Hour	MISO Gen Price	MISO Inadv MWh	MISO Inadv Revenue
1	$12.76	2	-$25.51
2	$14.18	3	-$42.55
3	$12.75	-2	$25.50

Advantages: Easier to calculate.

Disadvantages: Less accurate a representation of the value of inadvertent.

3.2. Handling of Inadvertent Revenue

Once the value of inadvertent energy is estimated the revenue surplus or shortage must be handled in settlement. The preferred solution is to accumulate the interchange revenue over a defined period then clear the interchange revenue account by settling with market participants. There are two options described below for managing this process.

3.2.1. Inadvertent Revenue Settlement Option 1 – Control Area Basis

This option distributes the inadvertent revenue surplus or shortage to each CA on an hourly basis. The revenue calculated in section 3.1.1 is simply credited or charged to CA in each hour.

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[1] MISO only knows actual interchange across all boundaries. The nature of electrical power flows is such that physical flows cannot be linked with scheduled transactions across boundaries

3.2.2. Inadvertent Revenue Settlement Option 2 – MISO Basis

This option distributes the inadvertent revenue surplus or shortage to MISO participants on a monthly basis. The MISO inadvertent revenue account starts the period with a zero balance. Each hour's inadvertent revenue is credited or debited to the account. At the end of each period (probably monthly) the account balance is distributed (if positive) or charged (if negative) to MISO participants in accordance with the same determents as used for Schedule 17 charges.

The size of the account is uncertain but it should balance to zero over time provided that MISO returns the inadvertent energy total to zero periodically.

3.2.3. Recommendation

The recommended solution for calculation of inadvertent revenue is Option 1 – Control Area Basis. This option provides the most accurate revenue modeling of inadvertent.

4. Related Issues

4.1. NERC Reporting

NERC requirements on control areas include reporting inadvertent interchange by control area. The values of scheduled and actual NSI are needed to perform this calculation. If this requirement cannot be varied (by seeking a NERC waiver) then the calculation will need to be supported. Actual interchange is calculated in the settlement process after the processing of generation, load, and loss for each CA's. Scheduled NSI can be calculated by integrating the dispatch (5 minute) NSI instructions.

This calculation is already done if Energy Accounting Option 1 – Maintain each CA inadvertent account separately or Energy Accounting Option 2 – Offset to Net CA are chosen. Energy Accounting Option 3 - Assign to a single ("Bank") CA would require more effort to implement while Energy Accounting Option 4 - Assign to MISO would require a NERC waiver in addition to additional implementation effort.

4.2. Tie Line Meter Error

Errors in tie line metering arise from differences between SCADA readings (which are used initially in interchange, load, and settlement calculations) and field tie line meter readings. Differences in the readings result in incorrect calculated values of CA load and actual interchange. There are three options for handling tie line meter error. The first two options are used currently, depending on the scale of the error. The third option is possible with MISO settlement.

4.2.1. Tie Line Meter Error Correction Option 1 – Scada Adjustment

In this option, observed tie line meter error is "paid back" by biasing the SCADA reading of the tie line for an agreed period in the future.

Based on the example above, if the tie line flow between the Control Areas was reading 5% high for the first hour, the reported interchange would be 1MW too high. This could be corrected in the second hour by adding 1 MW after-the-fact to what was observed in real time.

The results of this process are shown in the table below.

	Real Time Interchange (SCADA)		Actual Interchange (Meter)	
Hour	A Int MW	B Int MW	A Int MW	B Int MW
1	20.95	-8.95	19.95	-7.95
2	3.32	19.68	2.32	20.68
3	-12.58	40.58	-12.58	40.58

Initially, settlement is performed using SCADA data, with load calculated from generation and interchange values. Errors in SCADA interchange values result in incorrect load values. The tables below compare the loads and load payments between the correct and incorrect values.

	Real Time Interchange (SCADA)		Actual Interchange (Meter)	
Hour	A Load MW	B Load MW	A Load MW	B Load MW
1	48	97	49	96
2	88	85	89	84
3	91	62	91	62

	Real Time Interchange (SCADA)		Actual Interchange (Meter)	
Hour	A Load $	B Load $	A Load $	B Load $
1	$620.10	$1,233.30	$633.02	$1,220.58
2	$1,260.20	$1,197.55	$1,246.20	$1,211.97
3	$1,144.85	$815.50	$1,144.85	$815.50
Total	$3,025.15	$3,246.34	$3,024.07	$3,248.06

In hour 1, load in control area A is pays less than the correct value, and load in control area B pays more. The situation is reversed in hour 2 when the correction is made. Although the total payments are similar in both cases this would not generally be the case as prices way differ significantly between the error and correction periods.

If one control area is external to MISO then the result is similar except that there is no financial settlement of the external control area load.

4.2.2. Tie Line Meter Error Correction Option 2 – Inadvertent Adjustment

In this option, observed tie line meter error is corrected by an agreed adjustment to the accumulated inadvertent accounts of control areas.

Based on the example above, if the tie line flow between the Control Areas was reading 50% high for the first hour, the reported interchange would be 10MW too high. This could be corrected later by offsetting 10MW from each accumulated inadvertent total. The dispatch results are shown in the table below.

	Real Time Interchange (SCADA)		Actual Interchange (Meter)	
Hour	A Int MW	B Int MW	A Int MW	B Int MW
1	29.95	-17.95	19.95	-7.95
2	2.32	20.68	2.32	20.68
3	-12.58	40.58	-12.58	40.58

The accumulated inadvertent for each control area is shown in the table below.

	Real Time Interchange (SCADA)		Actual Interchange (Meter)	
Hour	A Inadv	B Inadv	A Inadv	B Inadv
1	9.41	-7.41	-0.59	2.59
2	20.73	-15.73	10.73	-5.73
3	24.39	-21.39	14.39	-11.39

The error in accumulated inadvertent can be corrected by agreeing to adjust control area A's total down by 10MW and control area B's total up by 10MW.

Initially, settlement is performed using SCADA data, with load calculated from generation and interchange values. Errors in SCADA interchange values result in incorrect load values. The tables below compare the loads and load payments between the correct and incorrect values.

	Real Time Interchange (SCADA)		Actual Interchange (Meter)	
Hour	A Load MW	B Load MW	A Load MW	B Load MW
1	39	106	49	96
2	89	84	89	84
3	91	62	91	62

	Real Time Interchange (SCADA)		Actual Interchange (Meter)	
Hour	A Load $	B Load $	A Load $	B Load $
1	$503.83	$1,347.73	$633.02	$1,220.58
2	$1,246.20	$1,211.97	$1,246.20	$1,211.97
3	$1,144.85	$815.50	$1,144.85	$815.50
Total	$2,894.88	$3,375.20	$3,024.07	$3,248.06

In hour 1, load in control area A pays less than the correct value, and load in control area B pays more. In this option there is not even partial correction of error in load payments.

If one control area is external to MISO then the result is similar except that there is no financial settlement of the external control area load, and the inadvertent correction will alter the MISO inadvertent accumulated total.

4.2.3. Tie Line Meter Error Correction Option 3 – Settlement Corrections

In this option observed tie line meter error is corrected by submitting updated information to the MISO settlement process, regardless of the magnitude of the error. The updated information is reflected in the next round of settlement for the period in error. Taking the example from the table above, the following table shows the correction that is made to load payments. The accumulated inadvertent totals would be corrected in the same way.

	Real Time Interchange (SCADA)		Adjustement to Settlement		Actual Interchange (Meter)	
Hour	A Load $	B Load $	A Load $	B Load $	A Load $	B Load $
1	$503.83	$1,347.73	$129.19	-$127.14	$633.02	$1,220.58
2	$1,246.20	$1,211.97			$1,246.20	$1,211.97
3	$1,144.85	$815.50			$1,144.85	$815.50
Total	$2,894.88	$3,375.20	$129.19	-$127.14	$3,024.07	$3,248.06

This option results in the correct payments by load in all control areas concerned, and correct values of accumulated inadvertent energy for all control areas and MISO.

If one control area is external to MISO then the result is similar except that there is no financial settlement of the external control area load, and the inadvertent correction will alter the MISO inadvertent accumulated total.

4.2.4. Recommendation

This issue has been deferred to the MSTF for resolution.

4.3. Handling existing inadvertent accounts

Each Control Area currently records and reports inadvertent interchange, and has an "account balance". Although it is desirable to zero out individual CA balances before the MISO start date, this is unlikely to be achieved.

Instead a mechanism for payback of "pre-MISO" inadvertent is necessary. This cannot be combined with the "post-MISO" system because the pre-MISO inadvertent energy does not have any associated revenue to be balanced. Using the MISO inadvertent to repay pre-MISO inadvertent would result in a MISO settlement surplus or shortage being applied to inadvertent incurred pre-MISO.

The general solution is to establish a special type of physical schedule (Inadvertent Repayment Schedules) that allows a CA to nominate the amount and destination of inadvertent payback. This schedule is identified for special handling in both settlement and inadvertent accounting.

4.3.1. Case 1 – Payback between MISO members

The first case considered is inadvertent payback with another MISO member. In this case a normal financial schedule is entered between the parties for the amount of inadvertent payback. This may be marked as a "Inadvertent Repayment Schedule" to allow correct settlement and reduction of inadvertent balances. This method will automatically include loss and constraint costs as in a normal financial schedule.

4.3.2. Case 2 Payback with external CA

The second case considered is inadvertent payback with a non-MISO member. In this case a physical schedule is needed. The first requirement is that the inadvertent correction must exit the MISO footprint. This is achieved by requiring schedules for correcting pre-MISO inadvertent to be physical schedules with an external control area. In settlement, a physical schedule used to correct pre-MISO inadvertent will not have any associated price or revenue, similar to a grandfathered schedule. It will also be specially marked for reduction of pre-MISO inadvertent balance.

The second requirement is that originating control area must not be paid (or pay) for the generation surplus or shortage that is needed to correct the pre-MISO inadvertent. Therefore the quantity denoted in the schedule is removed from the control areas generation before calculating generation revenue. Again, this type of special schedule would be denoted as an Inadvertent Repayment Schedule so it could be excluded from the settlement process and used to reduce the inadvertent account of the source Control Area.

4.3.3. Case 3 Unilateral Payback

The third case considered is unilateral inadvertent payback.

To be consistent with case 2, and to return the pre-MISO net inadvertent account to zero it is necessary that unilateral inadvertent payback be an export or import of MISO. This is achieved by requiring schedules for unilateral correction of pre-MISO inadvertent to be physical schedules with a special counterparty. In settlement, a physical schedule (Inadvertent Repayment Schedule) used to correct pre-MISO inadvertent will not have any associated price or revenue, similar to a grandfathered schedule. It will also be specially marked for reduction of pre-MISO inadvertent balance.

The second requirement is that originating control area must not be paid (or pay) for the generation surplus or shortage that is needed to correct the pre-MISO inadvertent. Therefore the quantity denoted in the schedule is removed from the control areas generation before calculating generation revenue. A special type of financial schedule could achieve this, again similar to the grandfathered schedule.

4.3.4. Recommendation

The recommended solution to existing inadvertent account balances is Case 3 – Unilateral Payback.

5. Appendix A Model with Losses and Constraints

Figure 1 shows a 2-control area model with generation and demand within each control area. In this example each control area is modeled with 3 generators and 1 load at a single electrical node. Losses and constraints are ignored initially. MISO dispatches generation to meet demand in each area and the total off-MISO schedule. Each control area receives a scheduled NSI control signal which sum to the required MISO NSI. Real time operation will have variations around scheduled NSI resulting in inadvertent interchange.

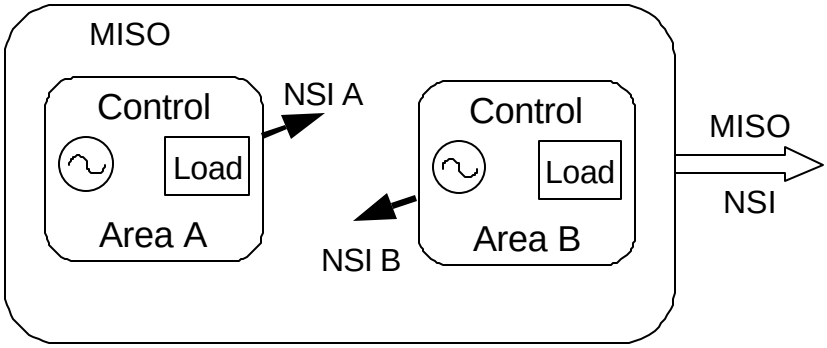

Figure 1 Multi Area Model Outline

Dispatched Energy: This table lists the hourly results based on the 5 minute RT dispatch process. In each hour, the CA NSI is the integration of the difference between scheduledCA generation and forecast CA load. The MISO NSI is the sum of the CA's NSI which is also equivalent to the net of external scehdules. The MISO NSI arises from a scheduled export from Control Area B to an external party.

	Control Area A			Control Area B			MISO
Hour	Gen MW	Load MW	NSI MW	Gen MW	Load MW	NSI MW	NSI MW
1	68.54	48	20.54	87.46	98	-10.54	10
2	80.	89	-9	100.	71	29	20
3	75.75	92	-16.25	103.25	57	46.25	30

Actual Quantities: This table lists the actual metered hourly values of generation, load, and interchange.

	Control Area A			Control Area B			MISO
Hour	Gen MW	Load MW	Int MW	Gen MW	Load MW	Int MW	INT MW
1	68.95	49	19.95	88.05	96	-7.95	12
2	91.32	89	2.32	104.68	84	20.68	23
3	78.42	91	-12.58	102.58	62	40.58	28

Prices: This table lists the generation, load, and transaction Pnode prices in each CA for each hour. The Pnode prices are net-injection-weighted averages of the five minute LMP's for the underlying Enodes. Hourly prices differ even when there are no losses or constraints because the load and generation weightings are different throughout the hour.

	Control Area A		Control Area B		
Hour	P_{GA}	P_{LA}	P_{GB}	P_{LB}	P_{TB}
1	$12.97	$12.92	$12.59	$12.71	$12.34
2	$14.19	$14.	$14.18	$14.43	$13.91
3	$12.85	$12.58	$12.68	$13.15	$12.33

Inadvertent Interchange: This table lists the difference between the dispatched NSI and actual interchange for each control area and MISO. Note that the CA inadvertent totals sum to the MISO total.

Hour	A MW	B MW	MISO
1	-0.59	2.59	2
2	11.32	-8.32	3
3	3.67	-5.67	-2

Settlement: Settlement is calculated from actual generation and load, and scheduled external transactions. This table lists the net settlement outcome for each control area and MISO.

Hour	A	B	External	MISO
1	-$261.06	$111.97	$123.43	-$25.66
2	-$49.61	-$272.31	$278.18	-$43.74
3	$137.19	-$484.89	$370.00	$22.30

The non-zero settlement outcome for MISO relating to indavertent interchange arises because of the difference between scheduled and actual external interchange. This can be either positive or negative as illustrated above.

These results are for the same model inputs, except that line losses are included and the line connecting the two control areas is constrained.

Dispatched:

	Control Area A	Control Area B	MISO

Hour	Gen MW	Load MW	NSI MW	Gen MW	Load MW	NSI MW	NSI MW^2
1	57.58	48	9.52	98.6	98.	0.48	10.
2	86.9	89.	-2.17	93.23	71.	22.17	20.
3	88.78	92.	-3.33	90.38	57.	33.33	30.

Prices: Note increased price seperation between nodes

	Control Area A		Control Area B		
Hour	P_{GA}	P_{LA}	P_{GB}	P_{LB}	P_{TB}
1	$10.26	$10.4	$14.44	$14.43	$13.74
2	$16.51	$16.92	$14.07	$14.44	$13.47
3	$16.95	$17.15	$12.36	$13.04	$11.58

Actual Quantities:

	Control Area A			Control Area B			MISO
Hour	Gen MW	Load MW	Int MW	Gen MW	Load MW	Int MW	INT MW
1	58.34	49.	9.25	98.84	96.	2.75	12.
2	91.9	89.	2.84	104.22	84.	20.16	23.
3	88.13	91.	-2.95	93.03	62.	30.95	28.

Inadvertent Interchange:

Hour	A MW	B MW	MISO
1	-0.27	2.27	2.
2	5.01	-2.01	3.
3	0.38	-2.38	-2.

Settlement:

Hour	A	B	External	MISO
1	-$88.82	-$41.94	$137.38	$6.62
2	-$11.27	-$253.49	$269.43	$4.66
3	$66.67	-$341.39	$347.45	$72.72

Inadvertent Energy Price Option 1 – CA basis

Hour	Gen Price A	Gen Price B	Inadv A Revenue	Inadv B Revenue	MISO Inadv Revenue
1	$10.26	$14.44	-$2.79	$32.80	-$30.01
2	$16.51	$14.07	$82.74	-$28.33	-$54.41
3	$16.95	$12.36	$6.37	-$29.36	$22.99

Inadvertent Energy Price Option 2 – MISO basis

Hour	MISO Gen Price	MISO Inadv MWh	MISO Inadv Revenue
1	$12.89	2.	-$25.77
2	$15.21	3.	-$45.64
3	$14.59	-2.	$29.18

6.

7. Appendix 1 Model with Losses

These results are for the same model inputs, except that line losses are included.

Dispatched:

	Control Area A			Control Area B			MISO
Hour	Gen MW	Load MW	NSI MW	Gen MW	Load MW	NSI MW	NSI MW
1	68.78	48	20.44	88.23	98.	-10.44	10.
2	80.84	89.	-8.75	100.	71.	28.75	20.
3	76.99	92.	-16.29	103.6	57.	46.29	30.

Prices:

	Control Area A		Control Area B		
Hour	P_{GA}	P_{LA}	P_{GB}	P_{LB}	P_{TB}
1	$11.98	$11.99	$12.91	$13.02	$12.59
2	$14.06	$13.91	$13.72	$14.07	$13.36
3	$13.03	$12.8	$12.2	$12.96	$11.85

Actual Quantities:

	Control Area A			Control Area B			MISO
Hour	Gen MW	Load MW	Int MW	Gen MW	Load MW	Int MW	INT MW
1	69.18	49.	19.7	88.78	96.	-7.7	12.
2	91.52	89.	2.37	104.78	84.	20.63	23.
3	79.16	91.	-12.32	102.81	62.	40.32	28.

Inadvertent Interchange:

Hour	A MW	B MW	MISO
1	-0.74	2.74	2.
2	11.11	-8.11	3.
3	3.97	-5.97	-2.

Settlement:

Hour	A	B	External	MISO
1	-$241.44	$103.83	$125.86	-$11.74
2	-$49.46	-$255.10	$267.15	-$37.42
3	$133.09	-$450.51	$355.46	$38.04

Inadvertent Energy Price Option 1 – CA basis

Hour	Gen Price A	Gen Price B	Inadv A Revenue	Inadv B Revenue	MISO Inadv Revenue
1	$11.98	$12.91	-$8.92	$35.42	-$26.51
2	$14.06	$13.72	$156.33	-$111.30	-$45.03
3	$13.03	$12.20	$51.75	-$72.84	$21.09

Inadvertent Energy Price Option 2 – MISO basis

Hour	MISO Gen Price	MISO Inadv MWh	MISO Inadv Revenue
1	$12.50	2	-$25.00
2	$13.88	3	-$41.63
3	$12.56	-2	$25.12