Investigation of Loop Flows Across Combined Midwest ISO And PJM Footprint

May 25, 2007

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Executive Summary

On June 28, 2006 Midwest ISO and PJM included a new Joint and Common Market (JCM) initiative in their status report to FERC to investigate loop flows across the combined Midwest ISO and PJM footprint. The new initiative is to provide details on plans and actions taken to address the problems of external loop flows. In that filing the RTO's stated they had "observed increases in loop flows through their system. These unscheduled flows have generally increased around 1,000 MW (about 200%) on the TVA-PJM and MECS-PJM interfaces, approximately 500 MW (about 100%) on the NY-PJM interface and 600 MW (about 60%) on the Michigan-Ontario interface. The Midwest ISO and PJM staff believe that these loop flows are contributing to FTR revenue deficiency as these flows take up space on flowgates. Additionally, the 2006/2007 annual Auction Revenue Rights allocation was negatively impacted by the increasing loop flow trend." The analysis and recommendations of this JCM initiative are included in this report.

The Midwest ISO and PJM have taken active steps to attempt to address the loop flow problem to the best of their abilities, but the Midwest ISO and PJM cannot unilaterally solve this interregional problem. The Midwest ISO and PJM have continued to work with neighboring entities through the JCM initiative, the Congestion Management Process Working Group (CMPWG), and the Four-Party Agreement Working Group to better understand and identify the causes of loop flows within these systems and to develop mitigation strategies to effectively manage these flows.

In order to better understand the impact that external market participants have on the creation of loop flows on the Midwest ISO and PJM systems, the Midwest ISO and PJM requested and received permission to obtain energy tag information from the Independent Electricity System Operator (IESO) of Ontario, the New York Independent System Operator (NYISO) and the Tennessee Valley Authority (TVA). The acquisition of this tag information required the execution of various agreements with IESO, NYISO, Hydro-Quebec, and the Independent System Operator-New England (ISO-NE). In addition, OATI required that each entity provide a release letter prior to the release of tag information to Midwest ISO and PJM. This process took up to five months to complete. This information gathering process was quite cumbersome and must be addressed through more open interregional data exchange agreements.

At the present time, the Midwest ISO and PJM have two means for addressing loop flows. The first method, the "TLR approach" was developed by NERC and is adequate to preserve reliability but is not well suited to address the harmful impact of loop flows on economic dispatch and congestion. The second method is the "Congestion Management Process" (CMP) that was developed by the Midwest ISO and PJM in the context of the Joint Operating Agreement (JOA) and related documents. The Congestion Management Process allows the Midwest

ISO and PJM to compensate each other for taking action to control loop flows. The Midwest ISO and PJM believe this approach is better suited to address the impact of loop flows on economic dispatch and congestion.

The Midwest ISO, PJM and TVA executed a Joint Reliability Coordination Agreement (JRCA) in April 2005, which includes a CMP that addresses how these two different congestion management methodologies (market-based and traditional) will interact to ensure that loop flows and impacts are recognized and controlled in a manner that consistently ensures system reliability.

Although IESO and NYISO operate markets comparable to those of the Midwest ISO and PJM, they currently are not parties to the JOAs requiring the calculation of market flows. The Midwest ISO and PJM have proposed to IESO and the NYISO the possibility of creating a regional Congestion Management Process that would allow for the calculation of market flow to determine the loop flow impact. The Midwest ISO and PJM believe that this proposed approach is necessary to address the continuing loop flow problems in the Lake Erie area and looks forward to working with IESO and NYISO to resolve this issue.

The Midwest ISO and PJM consider the larger issue of how to address loop flow on their borders between them essentially resolved. The Midwest ISO and PJM continue to refine and update the power flow studies and data points used in their joint Congestion Management Process in order to achieve greater accuracy. The CMP has worked well to date and has resolved many loop flow issues.

Recent efforts to address loop flows on the southern border have been directed primarily at removing incentives for transactions harmful to markets. An analysis conducted by PJM in the summer of 2006 of the tag information received for PJM and TVA transactions indicated that a portion of the loop flows on its system were a result of market participants scheduling energy to take advantage of differences in interface prices at PJM's borders. These prices were intended to attract beneficial counter-flows to relieve congestion. Scheduled transactions that do not result in actual flow of energy are loop flows that provide no such benefits, and the associated actual flow may even exacerbate the congestion.

PJM presented a summary of its analysis results to the PJM Market Implementation Committee on August 8, 2006, along with several potential actions to address the loop flows observed on PJM's southern interfaces. After due consideration of the available options, the PJM Market Implementation Committee (MIC) voted to collapse the Southeast and Southwest interfaces. With the full support of the PJM Market Monitoring Unit, PJM changed the pricing mechanism for interchange transactions at the Southeast and Southwest interface pricing points effective October 1, 2006. Through the end of March 2007, the change in interface pricing mechanisms have resulted in a positive change in the scheduling behavior of market participants with an overall net reduction in regional loop flow.

The Midwest ISO and PJM have, in cooperation with neighboring systems to the North, continued to expand on the analysis of energy tag information and historical scheduled and actual energy flow information to better understand the causes of loop flows in the Lake Erie area. Findings to date have not revealed any scheduling practices with a similar, direct negative impact on the Midwest ISO and PJM systems. The northern interfaces have many marketing entities providing schedules that primarily transfer energy from a single system to a single neighboring system, compared to the multiple control area links scheduled on the southern interfaces.

In addition, the Midwest ISO and PJM have completed an in-depth study to itemize the contributions to circulation flows around Lake Erie. A review of 2006 real-time hourly data found significant circulation flow around Lake Erie that is predominantly in a counter-clockwise direction (PJM to NYISO to IMO to MECS) observed to be as high as 1500 MW. In order to manage these circulation flows, the contributors to circulation flows need to be identified and have an agreed upon process that each contributor will follow when congestion occurs. Findings to date indicate that PJM generation-to-load flow creates a general clockwise contribution to Lake Erie circulation flow ranging from 200 to 500 MW. Midwest ISO generation-to-load flow creates a general counter-clockwise contribution to Lake Erie circulation flow ranging from 100 to 250 MW. IESO and NYISO are not parties to the JOAs that require the calculation of market flows and do not currently calculate their generation-to-load contributions to Lake Erie circulation flows. The Midwest ISO and IESO performed an off-line study that found IESO net market flows ranging from 125 MW to 275 MW in a counter-clockwise direction around Lake Erie for various days in 2006 and 2007. No such study has been performed with NYISO.

In addition to the market flows of Midwest ISO, PJM, IESO, and NYISO, the operation of the Phase Angle Regulators (PARs) by the four markets around Lake Erie can influence the amount of circulation flows. PARs are electro-mechanical devices that change the impedance on the system. They neither create flows nor absorb flows (except for insignificant losses). However, the presence of PARs will alter the direction of flows to follow a different electrical path. In many cases the PARs were designed for a specific purpose and are less effective at controlling flows during conditions that deviate from the design. There are a number of operating limitations that prevent the use of PARs to minimize circulation flows. Since the PARs are going to continue to be used to manage the specific conditions they were installed to manage and are not going to be able to continuously operate to minimize circulation flows, it is important that the IESO and NYISO contributions to circulation flows be identified in the Interchange Distribution Calculator (IDC) and subject to the same type of obligations as Midwest ISO and PJM when congestion occurs. The Midwest ISO and PJM have proposed to IESO and the NYISO the possibility of creating a

regional congestion management system that would allow for the calculation of market flow to determine the loop flow impact.

Four party talks between Midwest ISO, PJM, NYISO and IESO have resulted in some very positive discussions on actions that the parties can accomplish over the next several years relating to mitigating loop flow. These items include the following recommendations and future steps:

- Commissioning of the Michigan-Ontario PARs as soon as possible to mitigate the loop flows around Lake Erie
- IESO and NYISO should adopt a Congestion Management Process whereby they report their market flows to the IDC and participate with Midwest ISO and PJM to manage circulation flows around Lake Erie when congestion occurs
- Create an Energy Schedule Tag Archive that contains tag impacts, market flow impacts, and generation-to-load impacts for flowgates in the IDC

The Midwest ISO and PJM will continue to improve the accuracy and effectiveness of the market flow calculator and will work with affected parties to further refine the Congestion Management Process. This includes identifying mechanisms for mitigating significant loop flow impacts as part of the JOA process by developing a broader regional Congestion Management Process. The Midwest ISO and PJM currently calculate and post to the IDC all generation-to-load impacts on neighboring transmission facilities which are curtailable via the TLR process. A worthwhile enhancement to the existing Congestion Management Process would be the real-time calculation and accounting for generation-to-load impacts by all neighboring entities where such real-time calculations do not currently occur.

Introduction

On June 28, 2006 Midwest ISO and PJM first included the Investigation of Loop Flows Across the Combined Footprint as a JCM initiative in their status report to FERC. In that filing the RTOs stated they had "observed increases in loop flows through their system. These unscheduled flows have generally increased around 1,000 MW (about 200%) on the TVA-PJM and MECS-PJM interfaces, approximately 500 MW (about 100%) on the NY-PJM interface and 600 MW (about 60%) on the Michigan-Ontario interface. The Midwest ISO and PJM staff believe that these loop flows are contributing to FTR revenue deficiency as these flows take up space on flowgates. Additionally, the 2006/2007 annual Auction Revenue Rights allocation was negatively impacted by the increasing loop flow trend."

The analysis and recommendations of this JCM initiative are included in this report.

General Definitions

Unscheduled energy, also known as "loop" flow and "circulation" flow, results from the difference between the energy that is scheduled to flow across an interface connecting two control areas versus the amount of energy that actually flows across the interface between those two control areas. This difference in energy flow is created as a result of Ohm's law, which holds that electricity takes the path of least resistance in a parallel circuit. The configuration of any and every element of the electric grid determines this resistance or impedance that governs the flow of electricity.

Scheduled energy is transacted from a source area along a contract path and terminates at the sink area. These elements are specified in a contract definition known as NERC tags. The contract path is a chain of market transitions for tracking financial settlement, and is not necessarily the physics-based actual path of energy delivery. Contracts are made by market participants called Purchase-Selling Entities (PSEs) to exchange power between Scheduling Entities. In general, contracts are responsive to energy price differences between the scheduling entities, and short-term spot market conditions can greatly influence the amount of scheduling activity that occurs.

Balancing Authorities (BAs) are responsible for dispatching generation to minimize the difference between the actual and scheduled energy. Additionally, BAs help to support the interconnection frequency. These two elements define the Area Control Error (ACE) equation used in the balancing process.

The difference between schedule and actual energy flows are accumulated by Market Settlements in an Inadvertent Accounting process. Energy exchange is

settled based on scheduled contracts across an interface, and the difference is recorded in running totals of MW-hours.

Impacts of Loop Flow

When loop flows become large, they can have a significant effect on both reliability and the operations of markets. Under normal procedures, a control area will only allow schedules on an interface up to the Available Transfer Capability (ATC) limit. When a facility carries loop flow caused by an external area in addition to its expected flow, its market is impacted because it cannot allow additional contracts across an interface. This is referred to as "overuse" of a neighboring system's transmission system.

In addition to traditional loop flow reliability issues, LMP-based markets can be uniquely harmed by loop flow impacts. LMP markets work on the basis of actual and not imagined flows, and the pricing at nodal points intends to match the true flows of electricity. When the prices and true flows do not match, there may be a costly impact on electricity markets. These impacts may include one or all of a disruption to pricing signals intended to induce rational economic behavior, an under-funding of ARRs/FTRs and an exposure to behavior that exploits the incongruity between pricing and flows at Midwest ISO's and PJM's interfaces.

For example, PJM observed an increase in loop flows through the PJM system from October 2004 through the end of April 2006. These unscheduled flows were observed to have generally increased around 1,000 MW on the TVA-PJM and MECS-PJM interfaces and approximately 500 MW on the NY-PJM interface over this timeframe. Market participants scheduling energy around the PJM system was the only explanation for the origin of these flows, but the result was the actual, physical flow of energy across the PJM system. These loop flows contributed to the FTR revenue deficiency observed in the first quarter of 2006, as these additional flows can use up transfer capabilities up on PJM facilities and lead to limiting constraints.

Mitigating Loop Flow Impact

In bulk power systems, there are currently two means to address the problem of loop flows across a control area's interfaces. The first method, the "TLR approach" developed by the NERC, aims to reduce the harmful impacts of loop flow by curtailing transactions between areas. The second method is the Congestion Management Process that was developed by PJM and Midwest ISO in the context of the Joint Operating Agreement and related documents.

The *TLR approach* employs an IDC developed by the NERC to identify "transmission loading" and defines a process for requesting a neighboring entity

to redispatch (provide “relief”) in order to protect stressed transmission facilities. The IDC uses a simplified power-flow model to determine the impact of contracts on transmission facilities (referred to as flowgates), based on the Generation Control Area (GCA) and Load Control Area (LCA) that define the contract path. The IDC is operated by OATI, and is supported by all control areas in the Eastern Interconnection. The tool combines tagged contracts (via OASIS) with transmission, generation and load positions (via SDX), and generates contract-level impacts on flowgates. If a control area’s flowgate is loaded up to its reliability limit and is impacted by control area-to-control area contracts, the flowgate’s control area can initiate a Transmission Loading Relief (TLR) event to request the curtailment of the external contracts that are contributing to the flow on the flowgate in the direction of the reliability limit. With the contracts curtailed, the redispatch of the external areas should relieve loading on the constraint.

Midwest ISO and PJM have developed an alternative method to control loop flow between their respective systems. The Congestion Management Process allows for accurate calculation of the impact of an area’s generation-to-load flow on the transmission facilities of an external area. Unlike the IDC, each area uses its own internal power-flow models and response factors for calculating regional impacts. If a reciprocal flowgate is constrained, the control areas can request an economic redispatch of the neighboring area to relieve loading on the constraint, taking into consideration each area’s use of the facility compared to its historical flow entitlement. This process is referred to as a “Market-to-Market” event. The parties involved then compensate each other for the economic redispatch in the settlements process (see Diagram 1).

Market-to-Market Compensation: PJM and Midwest ISO, 2005 – Spring 2006:

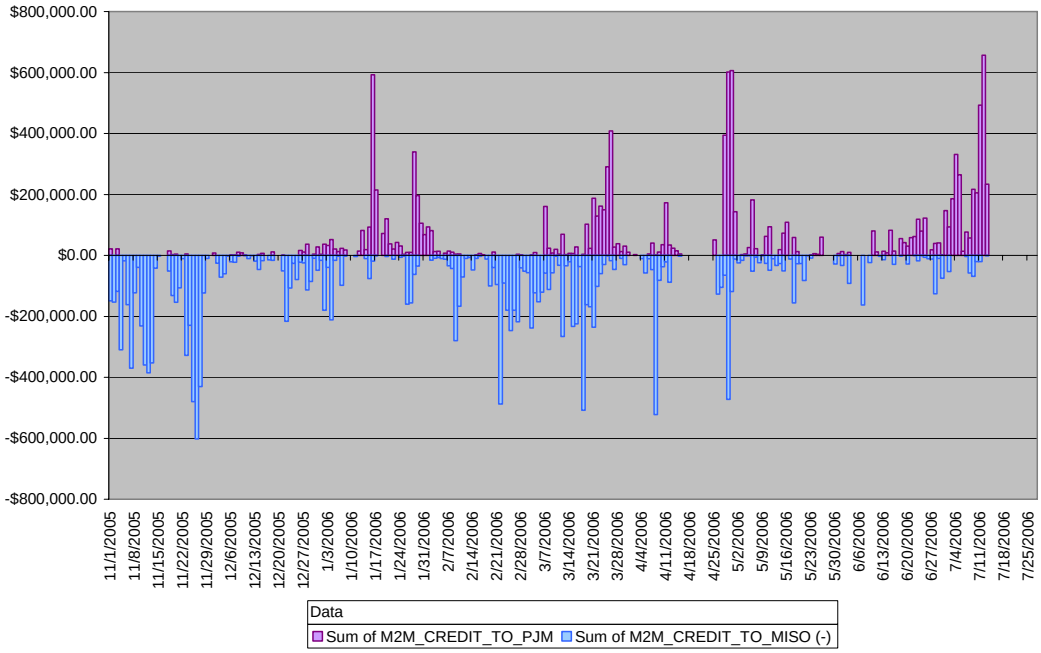

Diagram 1

The Congestion Management Process allows PJM and Midwest ISO to compensate each other for taking action to control loop flows. Because loop flow, as it relates to the parties, factors into pricing, this approach avoids harmful market distortions while maintaining the reliability of the transmission system. Using this method, Midwest ISO and PJM completely address the impact of loop flows as they relate to the internal flows generated on their respective systems (see Diagram 2).

Joint Loop Flow Research Areas

PJM Loop Flows by Interface Region, Average By Month 2006:

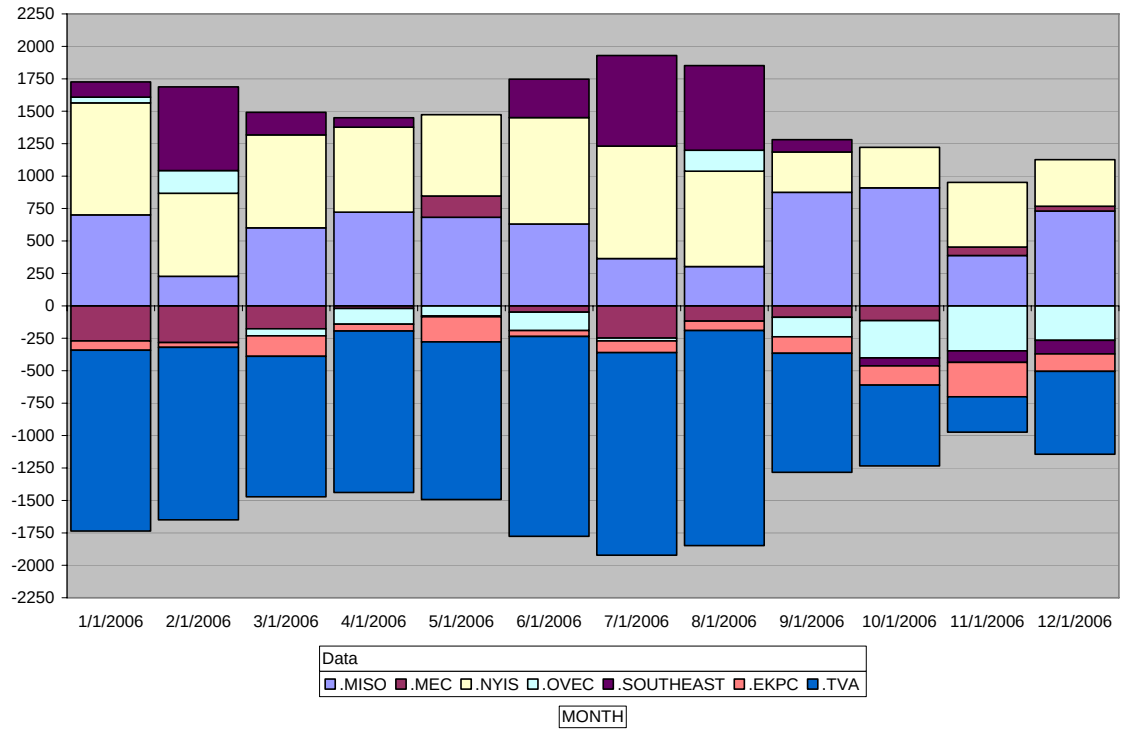

Diagram 2

FTR Revenue Adequacy

In April 2006, PJM staff expanded its investigation into finding and understanding the relationships between loop flows and their impact on FTR revenues. At the time, the money collected for FTR payments from the day-ahead clearing was inadequate to pay for congestion observed in the balancing market. At the time, stakeholders were considering the issue through the PJM Market Implementation Committee. Since loop flow is a real-time event, PJM believed that loop flows

were aggravating real-time constraints, causing additional binding hours and thus creating balancing congestion that was not predicted by day-ahead pricing.

PJM and Midwest ISO determined that the loop flow issue warranted further investigation. In order to better understand the impact that external market participants had on the creation of loop flows on the PJM system, PJM requested and received permission to obtain energy tag information from OATI for the scheduling areas of the IESO, Midwest ISO, PJM, NYISO and the TVA. The acquisition of this tag information required the execution of various agreements with IESO, NYISO, Hydro-Quebec, and the ISO-NE. In addition, OATI required that each entity provide a release letter prior to their release of the tag information to PJM and Midwest ISO. This process took up to five months to complete. This information gathering process was quite cumbersome and must be addressed through more open interregional data exchange.

PJM / Midwest ISO Seam

PJM and Midwest ISO consider the larger issue of how to address loop flow on this seam essentially resolved. The challenge for PJM in using the Congestion Management Process is to refine and update the power flow studies and data points used in order to achieve greater accuracy.

PJM requested and received from Midwest ISO additional real-time telemetry for Midwest ISO transmission to provide PJM with better modeling, monitoring and analysis of the sources of circulation. Over the course of 2006, many new stations and transmission facilities (in the former ECAR region) were incorporated into the PJM State Estimator to improve regional models. Concurrently, PJM staff worked with the Midwest ISO staff to confirm the accuracy of the market flow calculations. The market flow calculation is intended to quantify the impact one RTO's dispatch has on another RTO's transmission system. These calculations must correctly account for all flows induced on each RTO's system by the other RTO's generation to load dispatch.

PJM and Midwest ISO are continuously working to improve the accuracy and granularity of the market flow calculator. In the fall of 2006, an issue was identified with the Midwest ISO market flow data concerning the calculation of market flows in multi-element flowgates. A multi-element flowgate is a constraint where there are multiple transmission lines operating in parallel, with some lines acting as imports and others as exports. On December 20, 2006, Midwest ISO implemented a correction to its market flow calculator, resulting in more accurate flow measurements.

In the summer of 2006, PJM initiated the creation of a new flowgate series to monitor flows on its interchange ties to external control areas. The original "9000

series" flowgates allow a control area to calculate transaction impacts at an area-to-area (interface) level, which is essential for determining individual transactions that are creating loop flow. PJM found that the NERC interface flowgate representation had not kept up with PJM's market integrations of 2002 through 2005. In mid-October, PJM created 24 new flowgates (the "25000 series") including representations of PJM's current interchange ties. Since then, PJM has been able to use the new interface flowgates to measure its generation-to-load impacts on the external control areas, and will continue to monitor the flowgates for excessive loop flow impacts.

PJM and the Midwest ISO plan to continue efforts to further refine the Congestion Management Process, identify mechanisms for mitigating significant loop flow impacts external to both systems as part of the JOA process, to work with Midwest ISO to solve the loop problems to the north, particularly around Lake Erie, by developing a broader regional Congestion Management Process with Ontario's IESO and the New York ISO.

PJM Southern Interfaces

An analysis by PJM in the summer of 2006 of the tag information received for PJM and TVA transactions indicated that a portion of the loop flows on its system were a result of market participants scheduling energy to flow through the PJM as counter flow in order to take advantage of differences in interface prices at PJM's borders. These prices were intended to attract beneficial counter flows to relieve congestion. Scheduled transactions that do not result in an actual flow of energy are "loop" flow that provides no such benefits, and the associated actual flow may even exacerbate the congestion.

An examination of the southern interfaces on the 10 best and worst circulation hours of Spring 2006 revealed that on the worst circulation days, PSEs were creating contracts that sourced from distant areas Southeast of PJM sinking in PJM, and simultaneously making contracts sourcing from PJM sinking to areas Southwest of PJM. The primary interface of interest was the TVA interface with PJM, due to the large mismatches observed between schedule and actual energy flows.

An analysis of the energy tag information for the southeast and southwest PJM interfaces revealed that energy suppliers scheduled energy along the Florida-Southern-TVA-PJM path and energy along the PJM-TVA-Entergy path for the same period. On a separate southern interface, another supplier was observed scheduling 1,000 MW into PJM during times of high loop flows with no energy scheduled into PJM during times of low loop flows. On a third southern interface, yet another supplier that generally schedules 1,200 MW to PJM would, on days of high circulation, wheel over 400 MW of energy through PJM to Midwest ISO.

In these instances, little to none of the actual energy flows over the scheduled path through PJM but the scheduled energy still receives the incentive pricing (see Diagram 3).

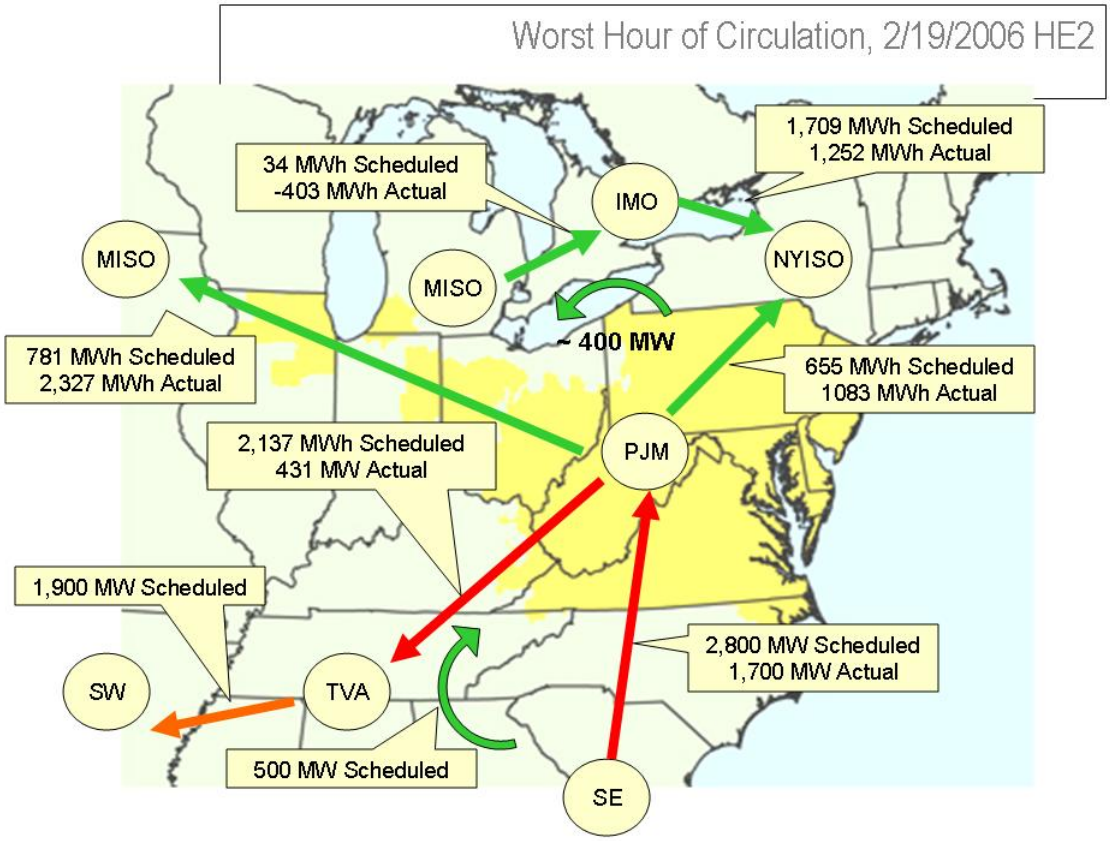

Diagram 3

PJM became increasingly concerned about instances where the source and sinks of contracts seemed responsive to price separation in the PJM Market but there was little or no actual flow into the PJM transmission system that would relieve the constraint. PJM settles contracts by mapping the source and sink control areas indicated on the NERC tags for those contracts to PJM pricing interfaces. Certain constraints could cause a pricing split on the interfaces which, combined with the above pricing mapping, encourages a market participant to submit wheel schedules through PJM even where there may be no actual delivery of energy.

PJM presented a summary of its analysis results to the Market Implementation Committee (MIC) on August 8, 2006, along with several potential PJM actions to address the loop flow observed on the TVA interface with PJM. After due consideration of the available options, the MIC voted to collapse the Southeast and Southwest scheduling interfaces. With the full support and agreement of the PJM Market Monitoring Unit, PJM changed the pricing mechanism for interchange transactions at the Southwest and Southeast interface pricing points effective October 1, 2006. The decision to merge the Southwest and Southeast

interface pricing points was publicly announced August 31, 2006. Within days, PJM observed changes in the scheduling behavior on its southern interfaces (see Diagrams 4 and 5).

Circulation Pre / Post 2006 Southern Interface Consolidation:

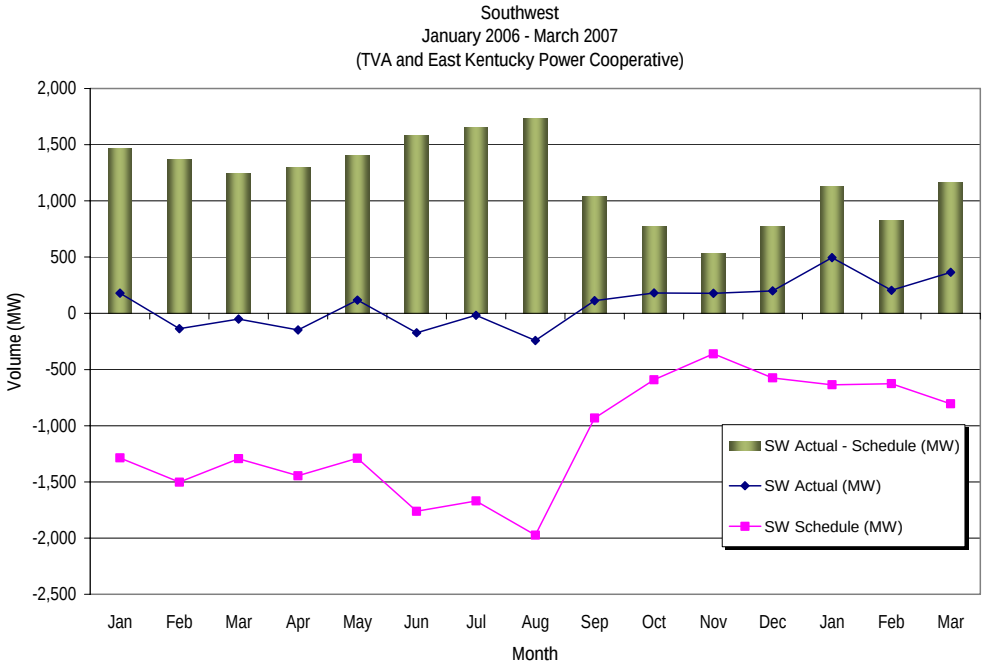

Diagram 4

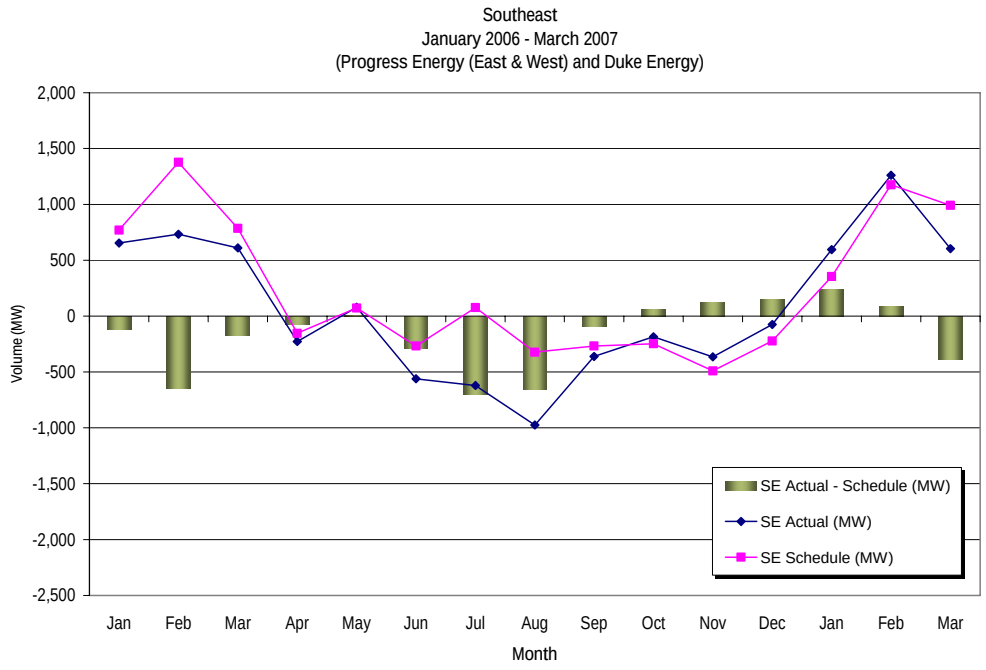

Diagram 5

Through the end of March 2007, the change in interface pricing mechanisms on the Southeast and Southwest interfaces resulted in a positive change in the scheduling behavior of market participants, with an overall net reduction in regional loop flow. Nonetheless, since 2006, inadvertent flows from the Duke and Progress control areas have continued to rise (see Diagram 6).

Monthly Average CPL & DUKE Circulation Comparison, 2006 to Spring 2007:

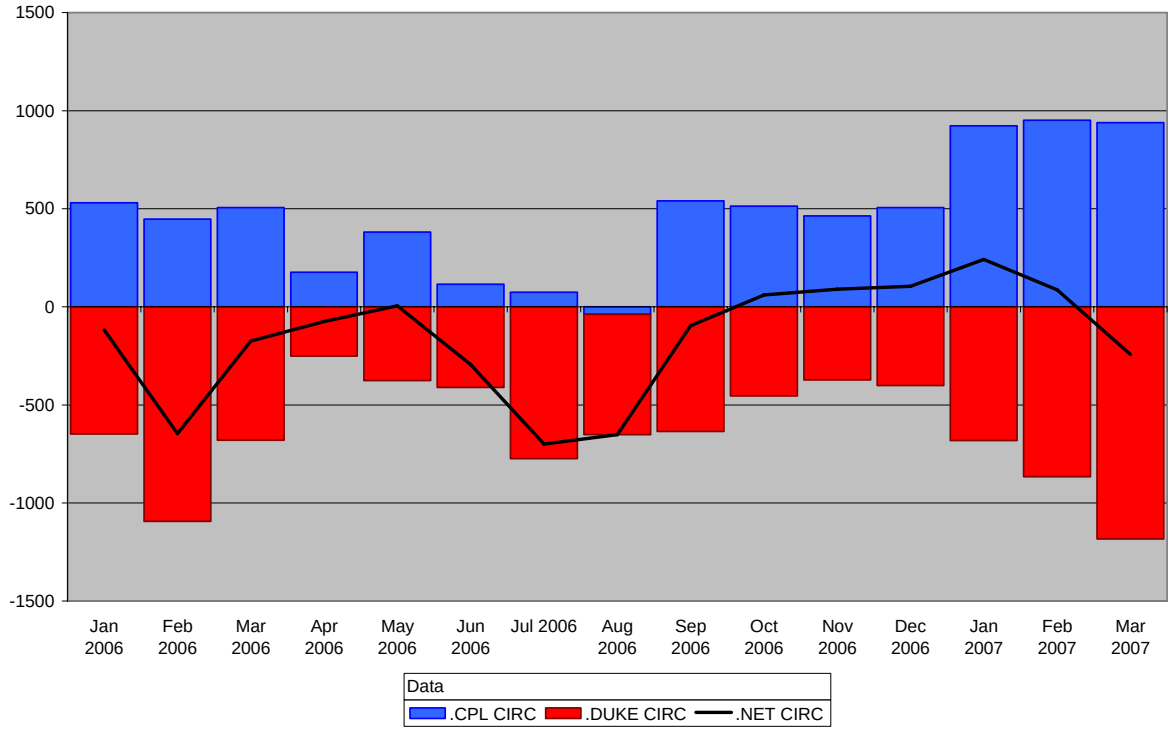

Diagram 6

Using the 25000 series flowgates, PJM was able to calculate its generation-to-load impacts on the southern flowgates. The findings show that PJM has a definite net forward impact on the Duke interface, with additional actual energy looping in on the TVA and CPLE interfaces. This corresponds to loaded generation in the ComEd and AEP territories flowing out to Ameren and Cinergy, then flowing back in on the TVA and CPLE interfaces to serve Dominion load (see Table 1).

January 1, 2007 through March 4, 2007 Average PJM Market Flow on Neighboring Systems				
Interface	PJM-CPLE	PJM-CPLW	PJM-Duke	PJM-TVA
Average PJM Market Flow (MW)	-546	28	221	-290

Table 1

The Midwest ISO and PJM will continue to improve the accuracy and effectiveness of the market flow calculator and will work with affected parties to further refine the Congestion Management Process and identify mechanisms for

mitigating significant loop flow impacts as part of the JOA process by developing a broader regional Congestion Management Process. The Midwest ISO and PJM currently calculate and post to the IDC all generation-to-load impacts on neighboring transmission facilities which are curtailable via the TLR process. A worthwhile enhancement to the existing Congestion Management Process would be the real-time calculation and accounting for generation-to-load impacts by all neighboring entities where such real-time calculations do not currently occur.

Lake Erie Circulation

Overview

ITC identified a number of dates in 2005 when they experienced high flows across the Michigan-Ontario interface. Four dates were selected for further review. Two involved dates when there were high clockwise flows around Lake Erie (going from MECS to IMO to NY to PJM) on February 17, 2005 and April 16-17, 2005, and two involved dates when there were high counter-clockwise flows around Lake Erie (going from PJM to NY to IMO to MECS) on March 1, 2005, and June 23, 2005. Two of the dates were prior to the start of the Midwest ISO market (February 17, 2005 and March 1, 2005) and two were following the start of the Midwest ISO market (April 16-17, 2005 and June 23, 2005).

An analysis was performed on the magnitude of the circulation flows, their direction and the time of day they occurred. The scheduled transactions across each of the interfaces around Lake Erie were evaluated by looking at individual tags and a composite of all tags. This provided the ability to check for a correlation between scheduled transactions and circulation flows. It also provided the ability to check whether certain individuals were able to influence circulation flows through their scheduling activity. The analysis found similar patterns during dates with high clockwise flows and during dates with high counter-clockwise flows. The following conclusions can made for each of these pairs of dates.

Days with High Clockwise Flows

(February 17, 2005 00:00-05:00 and April 16-17, 2005 23:00-07:00)

High clockwise flows going from MECS to IMO occurred during off-peak hours on both of these days. A review of scheduled transactions across each interface for each hour of high flows was accomplished by summing the tags on each interface (see Diagram 7). The left side of the diagram shows schedules between IMO and MECS, IMO and NY, and IMO and HQ from the IMO perspective (negative into IMO and positive out of IMO). The right side of the diagram shows schedules between PJM and NY from the PJM perspective (negative into PJM and positive out of PJM). Although the diagram only shows the composite of all tags across each of the interfaces, the review also looked at

the details of each tag in terms of the size of the tag, who was the PSE, what was the ultimate source and sink, etc. This level of detail is not provided in the diagram because data confidentiality agreements that allowed access to tags prohibit providing individual tag details.

Schedule MW, by Interface

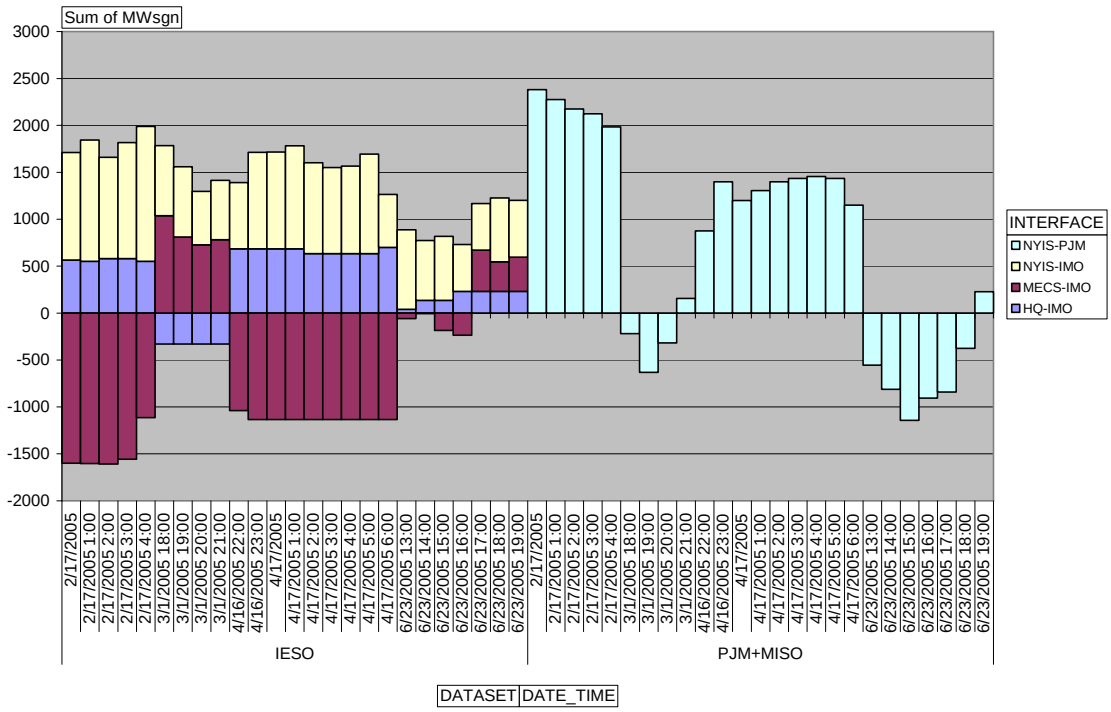

Diagram 7

A second review of the circulation flow during one hour on both of these dates was accomplished by plotting the actual flow versus the scheduled flow across each interface on a bubble diagram and plot (see Diagrams 8 and 9 for February 17, 2005 and Diagrams 10 and 11 for April 16 through 17, 2005). Actual flows on the AC system are identified separately from DC tie flows. It should be noted that the scheduled flow between IMO and HQ is accomplished by switching generation and load between the two systems. There are no synchronous ties between these two systems. The result is a generation and load transfer that does not contribute to loop flows. It should also be noted that the schedule flow and actual flow between Midwest ISO and PJM represents all ties and all schedules (including AEP, DPL, and ComEd) between the two RTOs. While the diagram shows separate bubbles for MECS, FE and Midwest ISO Other, the schedule flow and actual flow between Midwest ISO and PJM includes all Midwest ISO CAs in those two values. The actual flows are determined by summing actual flows on each of the tie lines that form the interface (these are hourly integrated values). The schedule flows are determined by summing the schedules across each of the interfaces.

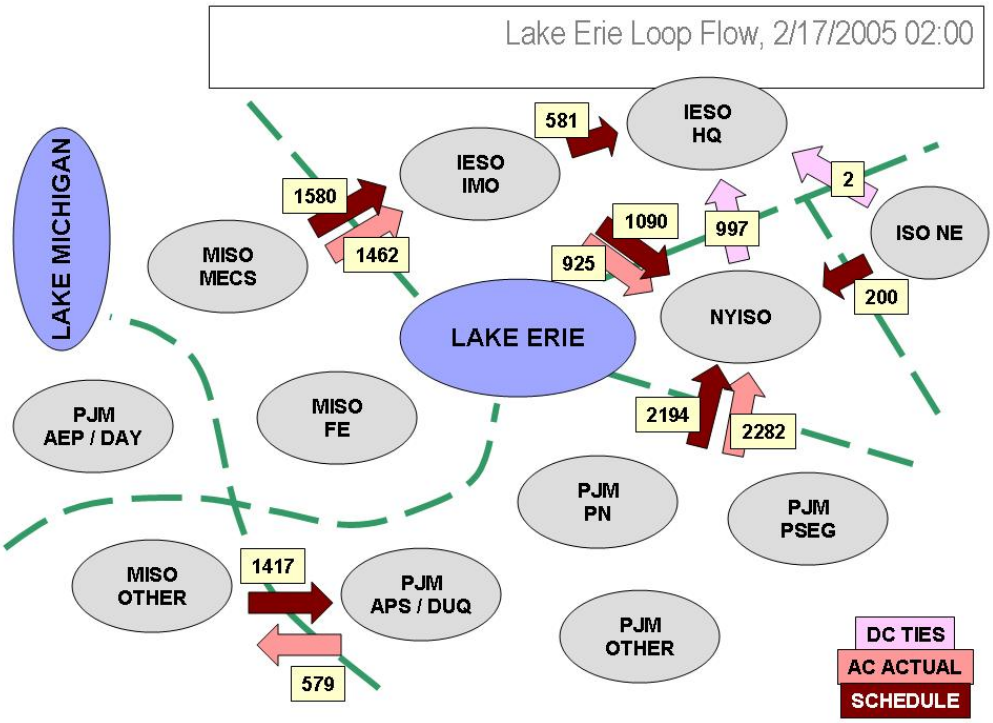

Diagram 8

Telemetry Hourly Averages, 2 / 17 / 2005

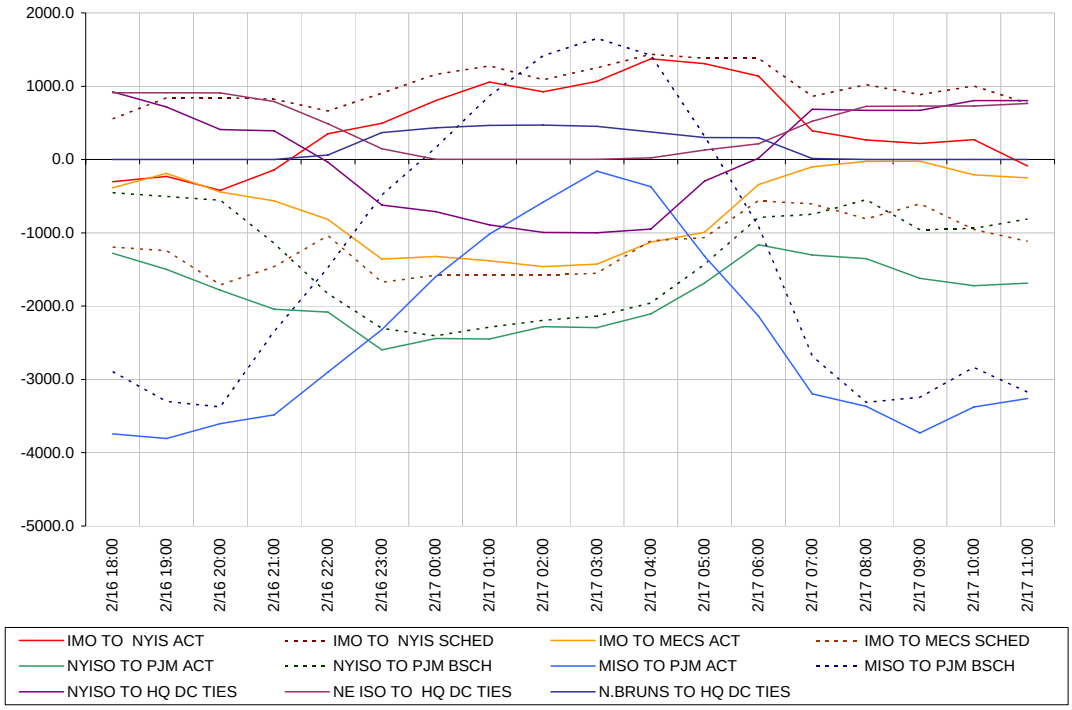

Diagram 9

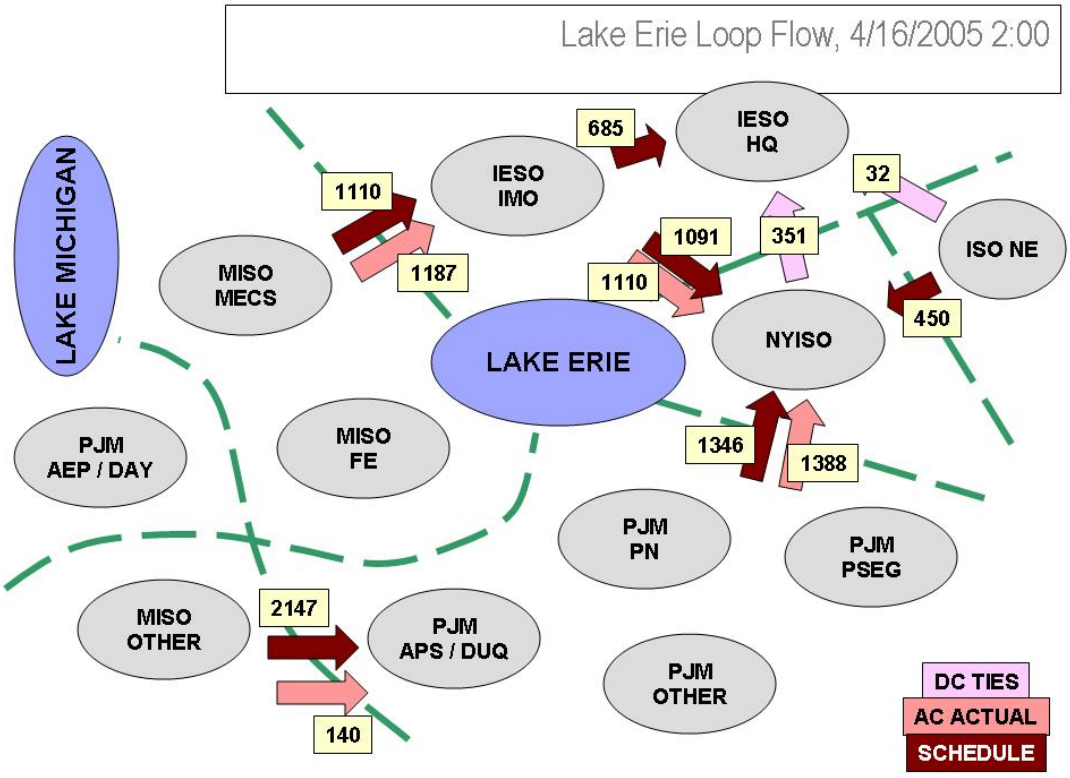

Diagram 10

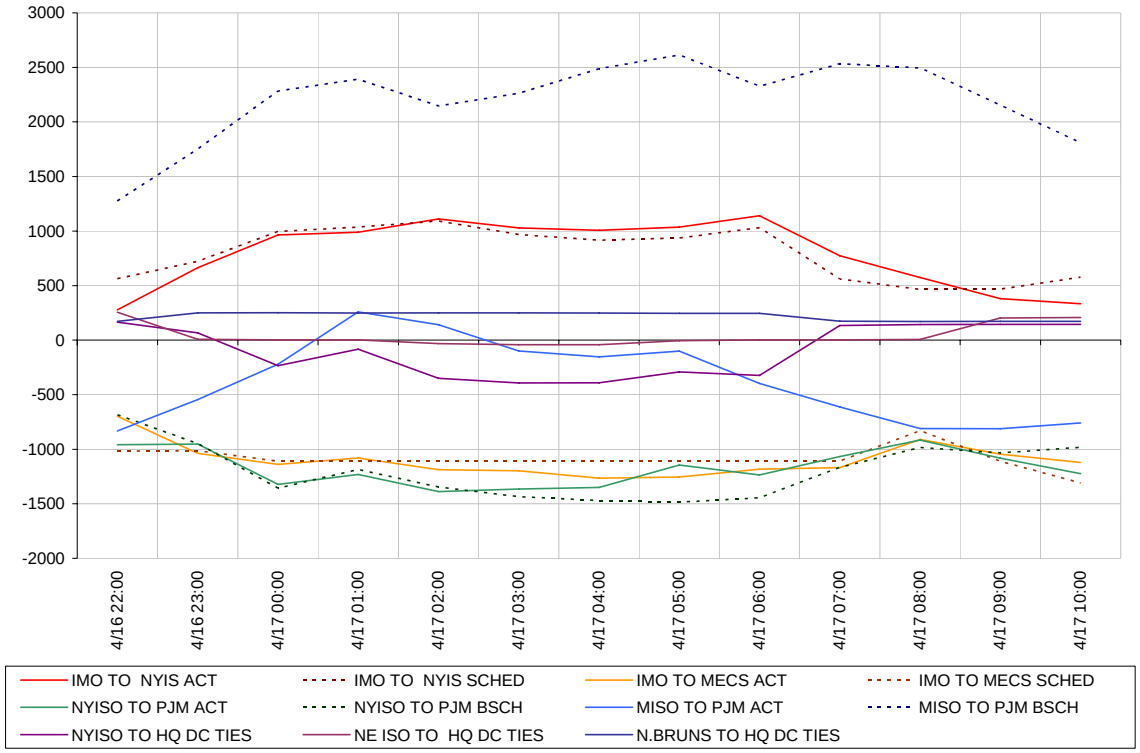

Diagram 11

Several observations can be made concerning Lake Erie circulation flows during off-peak hours on these two days:

- Even though ITC saw high Michigan-Ontario flows on these two days, there were also high Michigan-Ontario schedules on these same two days. In fact, there is good alignment between schedule flow and actual flow indicating there is very little Lake Erie circulation flow.
- A review of tags found between 1000 MW and 1500 MW of scheduled transactions from MECS to IMO, approximately 500 MW of scheduled transactions from IMO to HQ, approximately 1000 MW of scheduled transactions from IMO to NY and between 1000 MW and 2400 MW from PJM to NY. In general, the IESO imports from MECS are offset by off-system sales to HQ and NY. Also, NY imports power from IMO and PJM during off-peak hours.
- The occurrences of low Lake Erie circulation flows coincide with large net schedules from PJM to NY and the occurrences of high Lake Erie circulation flows coincide with small net schedules from PJM to NY or even schedules from NY to PJM. A contributor to this effect may be the natural bias of the PARS on the PJM to NY interface that are used to deliver power into NY.
- The tags were submitted by different entities on each of the interfaces. These tags represent purchases and sales between the markets and are not a coordinated effort by one or several entities to wheel power from MECS across Ontario, to get to the NYISO market.
- There is a similar pattern in the flows on these two days. The flows do not appear to be impacted by the start of the Midwest ISO market on April 1, 2005. The contribution of Midwest ISO and PJM market flows to the circulation flows are described later in this report.

Days with High Counter-Clockwise Flows

(March 1, 2005 19:00-22:00 and June 23, 2005 13:00-19:00)

High counter-clockwise flows going from IMO to MECS occurred during on-peak hours on both of these days. A similar review of scheduled transactions for each hour of the high flows and a review of circulation flows during one hour on both dates was accomplished (see Diagrams 12 and 13 for March 1, 2005 and Diagrams 14 and 15 for June 23, 2005).

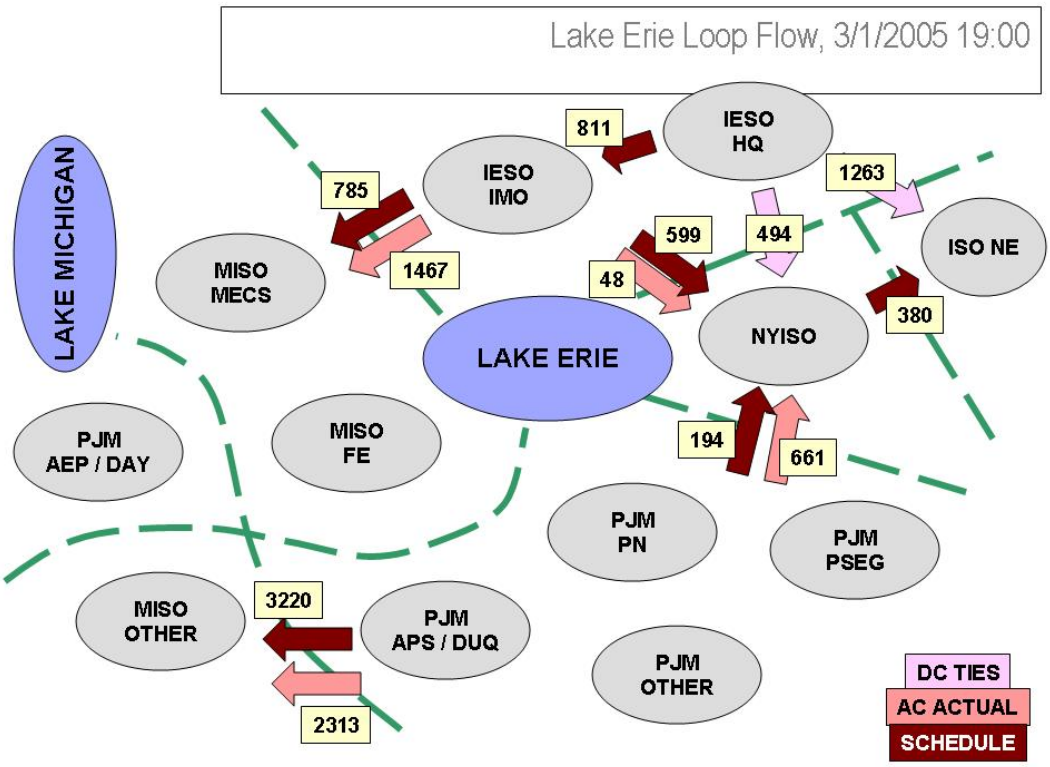

Diagram 12

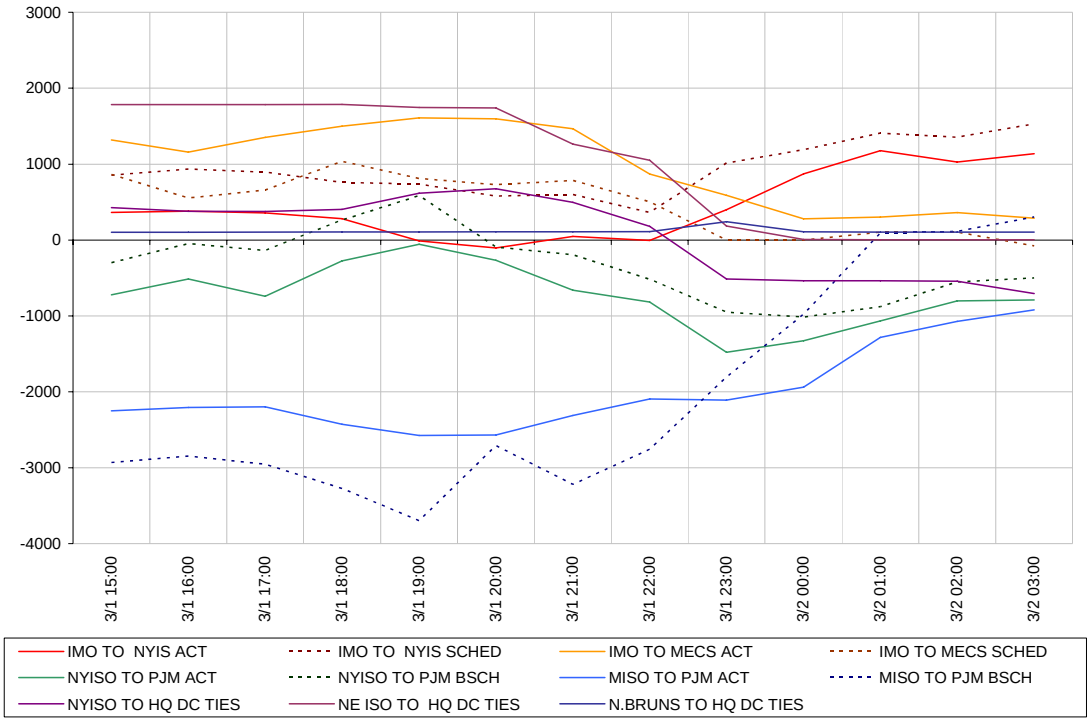

Diagram 13

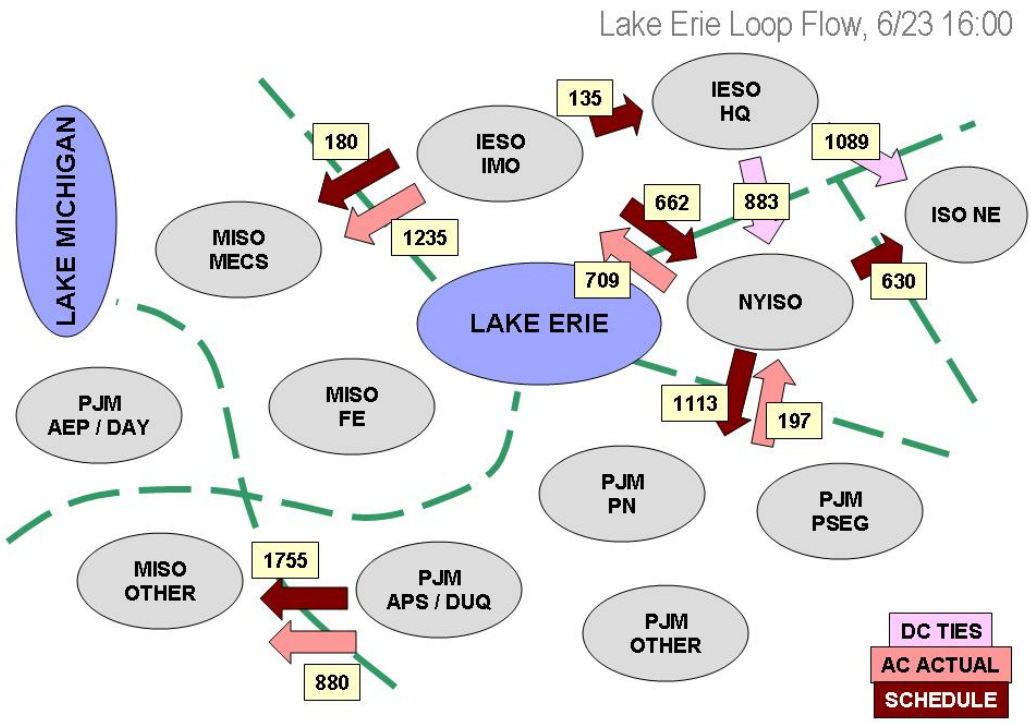

Diagram 14

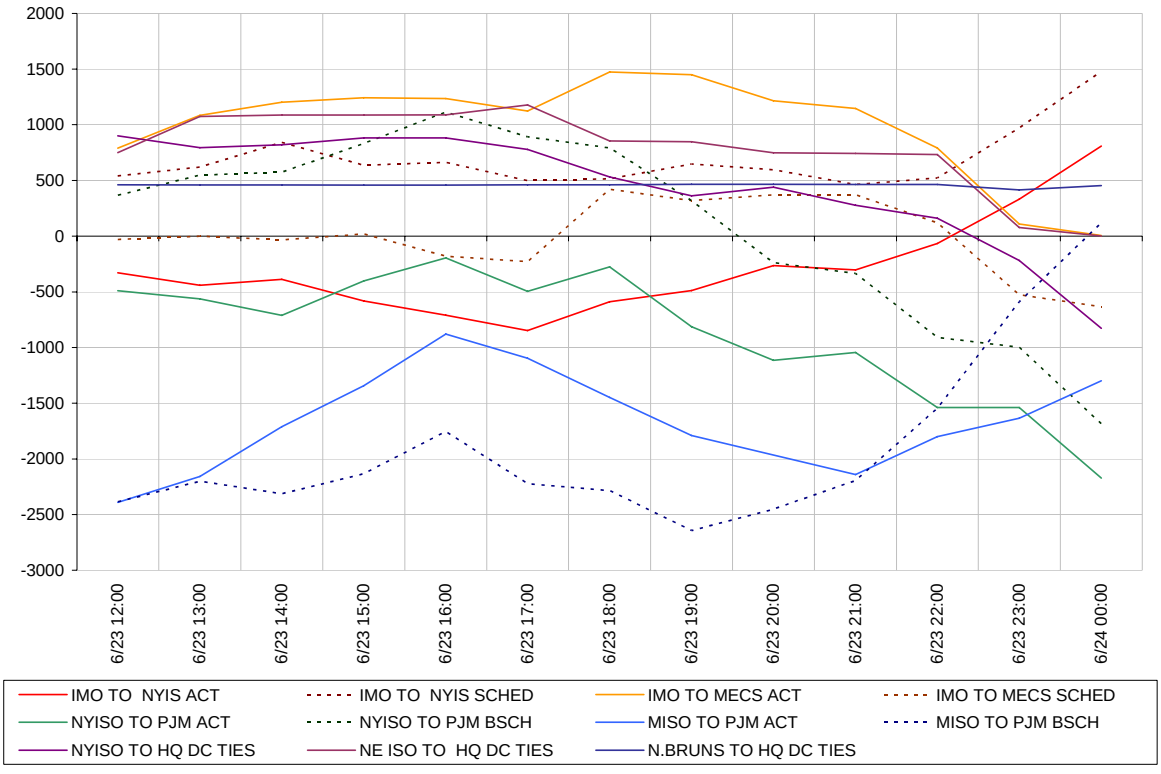

Diagram 15

Several observations can be made concerning Lake Erie circulation flows during on-peak hours on these two days.

- During these on-peak hours, there are high counter-clockwise actual flows with much smaller counter-clockwise schedule flows or schedule flows that are clockwise around Lake Erie. Because of the difference between schedule and actual flows, this produces very high counter-clockwise circulation flows. This occurs both pre and post Midwest ISO market start.
- During these on-peak hours, there are either very few tags from MECS to IMO or the tags are in the opposite direction from IMO to MECS compared to the off-peak hours. However, there continue to be tags from IMO to NY but at a reduced amount compared to the off-peak hours. The tags between IMO and HQ are also at a reduced amount and are going in a different direction on the two days. The tags from PJM and NY have been reduced to either very small amounts or amounts scheduled in the opposite direction from NY to PJM.
- Large circulation flows that coincide with the time periods when there are low PJM to NY schedules or the schedules are flowing in the opposite direction. This result supports the observation that when schedule flows are in a direction that is counter to the bias of the PARS on the PJM to NY interface, there are large counter-clockwise circulation flows.
- It is much more difficult to see a relationship of the schedules between Midwest ISO and PJM. A single actual value represents the sum of all ties between Midwest ISO and PJM and a single schedule value represents the sum of all tags between Midwest ISO and PJM. In general, it appears that Midwest ISO schedules are into PJM during off-peak hours although the actual flows may be in either direction and PJM schedules are into Midwest ISO during on-peak hours with actual flows into Midwest ISO at a lower amount than schedule flows.

Lake Erie circulation flow is defined as the difference between actual flow and schedule flow on the interfaces of the four markets around Lake Erie (Midwest ISO, IESO, NYISO, and PJM). There are a limited number of ties between Midwest ISO and IESO, between IESO and NYISO and between NYISO and PJM, which provide good points to measure circulation flow. The circulation flow on these three interfaces will also be present on the PJM to Midwest ISO interface but may be more difficult to measure because of the large number of ties that make up this interface.

The first part of this study looked at dates and times when ITC observed high Michigan-Ontario flows. The determination of a correlation between schedule flow (and their corresponding tags) versus actual flow at distinct time periods was the purpose of this study effort. The second part of the study, was expanded to identify any patterns that may exist. The diagrams below show integrated hourly actual flows versus hourly schedule flows for December 2006 and January 2007 on each of the three interfaces. While the actual flows and schedule flows are

unique for each of the three interfaces, the difference between actual flow and schedule flow are defined as Lake Erie circulation flow is almost identical on each of the three interfaces (see Diagrams 16 through 18). Superimposing the Lake Erie circulation flow from all three interfaces on a single diagram (see Diagram 19) illustrates how closely these flows align during all time periods.

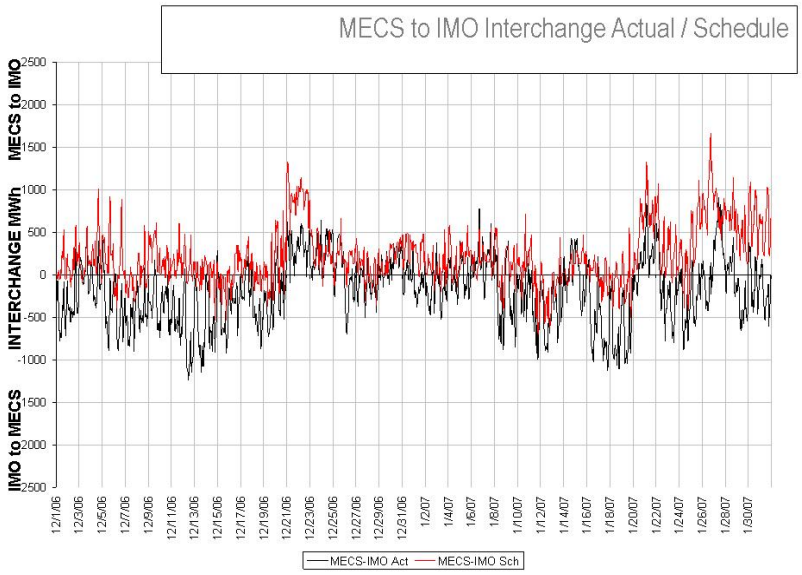

Diagram 16

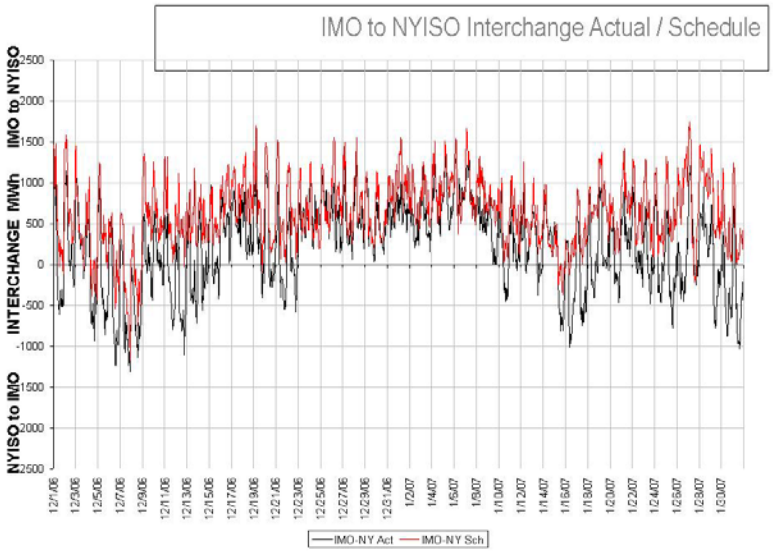

Diagram 17

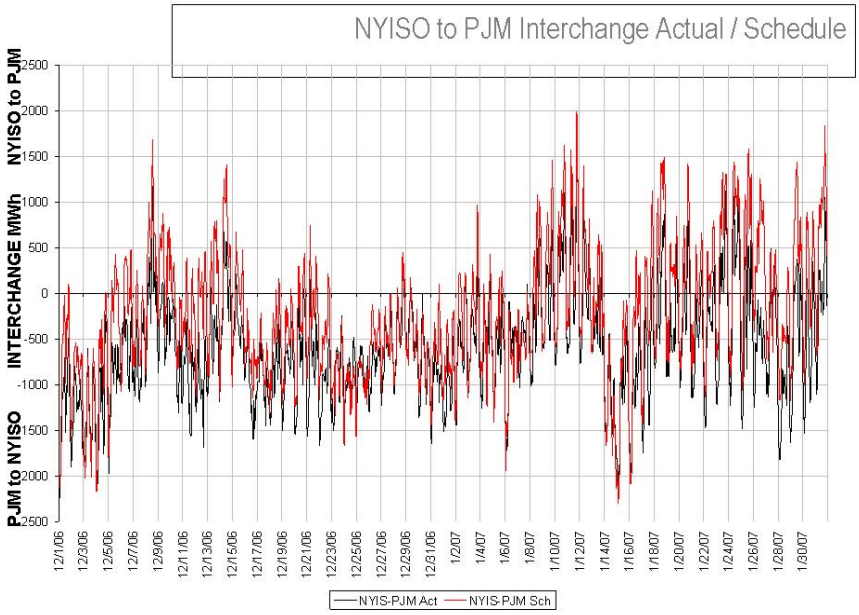

Diagram 18

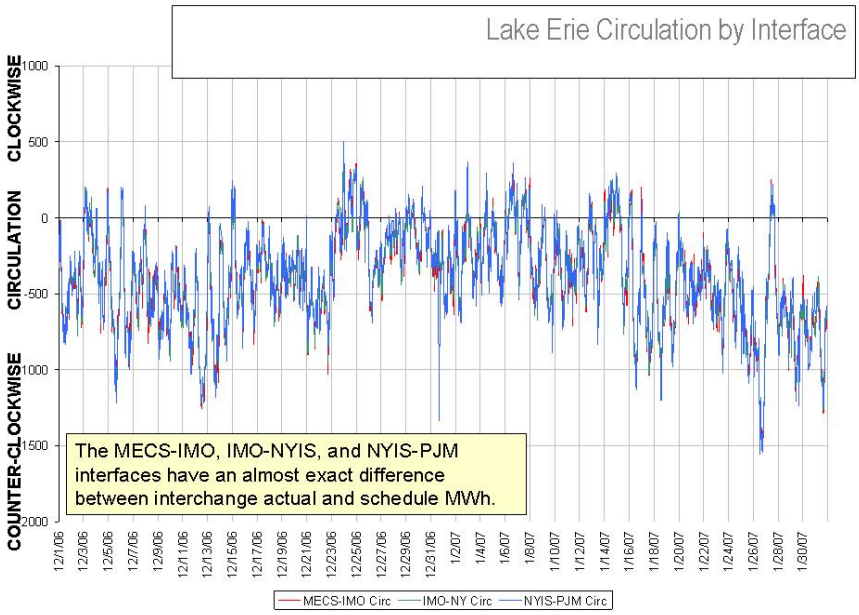

Diagram 19

There are several observations from the Lake Erie circulation flow diagram:

- For the two months plotted, a predominant counter-clockwise circulation flow exists.
- The circulation flows are highly volatile (swinging over 1000 MWs in a couple hours). They range between 1500 MW in the counter-clockwise direction to 500 MW in the clockwise direction for the two months plotted.

- Without expanding the range, it is difficult to say whether a daily pattern exists during the on-peak versus off-peak hours.
- It should be noted that on January 26, 2007, there was a significant circulation flow swing from 1500 MW counter-clockwise to 250 MW clockwise.

In this third part of the study, the scope was expanded further to examine circulation flow during all hours of 2006. This part of the study is not looking at either daily or hourly patterns but is doing a statistical analysis of each month in 2006 (the average for the month, values that fit within a plus or minus 25% bandwidth, values that fit within a plus or minus 48% bandwidth and any outliers beyond the plus or minus 48% bandwidth) and a statistical analysis on all data points in 2006.

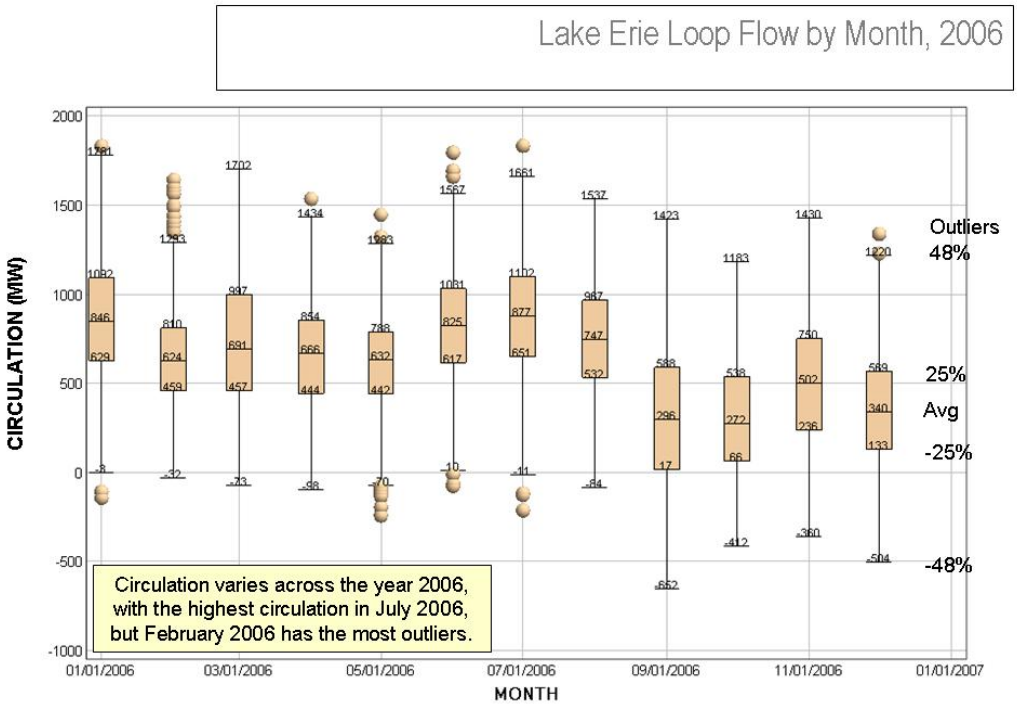

Diagram 20

Starting with the diagram that contains 2006 monthly circulation flows (see Diagram 20), the following observations can be made:

- The diagram shows the average and variances of the Lake Erie circulation flow measured on the NY-PJM interface. The median line is the average for the month. The box contains the range that represents 50% of all data. The whiskers contain “1.5x the inter-quartile length”, which approximates

to the range of 96% of the data. Any data points that are then significantly outside of the whiskers are plotted as outliers.

- In this diagram, a positive value indicates counter-clockwise circulation. All 12 months have an average counter-clockwise circulation with July having the highest average counter-clockwise circulation (877 MW) and October having the lowest average counter-clockwise circulation (272 MW).
- The volatility of monthly circulation flows can be measured by looking at the spread of values plus or minus 25% around the average (contains 50% of all points), by looking at the spread of values plus or minus 48% around the average (contains 96% of all points) and by looking at the spread of the outlier points outside the plus or minus 48% range. While all months show significant volatility, September 2006 has the widest spread for all points within plus or minus 48% and February 2006 has the narrowest spread for all points within plus or minus 48% but has the most outliers.

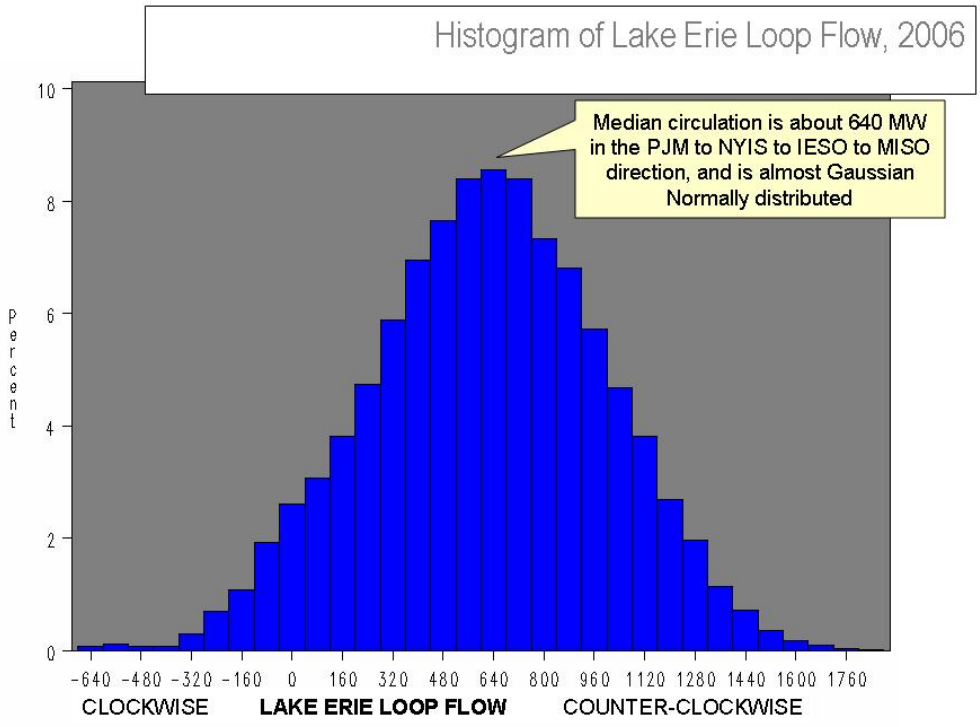

Diagram 21

A statistical analysis was performed on all 2006 data points and a histogram was plotted of the Lake Erie circulation flow (see Diagram 21). The analysis found a

median circulation of 640 MW in the PJM-NYISO-IESO-Midwest ISO counter-clockwise direction that is almost Gaussian normally distributed.

Phase Angle Regulators on PJM-NY Interface

The operations of the Phase Angle Regulators on the PJM-NY interface are in accordance with two transmission agreements between ConEd and PSE&G that were executed in 1975 and 1978 (the "400 MW contract" and the "600 MW contract, respectively). Together, the 600/400 MW contracts entitle ConEd to transfer up to 1,000 MW from points west of New York City through the PSE&G transmission system for re-delivery into New York City from the Southwest.

The 600/400 MW contracts were developed before the advent of wholesale market competition, open-access transmission service, and locational marginal pricing. Although their implementation has been the responsibility of the NYISO and PJM, there has never been a clear understanding of how the ISOs should administer the 600/400 MW contracts in the context of the advanced electricity markets that now exist in the NYISO and PJM regions, which has led to much controversy.

In addition to the PARs on the PJM-NY Interface, there are a number of PARs on other interfaces around Lake Erie. These are:

- PJM and NYISO are currently administering a transmission agreement between member companies PSE&G and ConEd. The agreement calls for 1000 MW of flow from ConEd into PSE&G at the Waldwick station (JK) and 1000 MW of flow from PSE&G to ConEd at Linden and Hudson (ABC). The Ramapo PAR is typically used to manage flows from PJM to NYISO.
- There is a PAR on the St. Lawrence interface between NYISO and IESO.
- Of the four ties between MECS and IMO, one is controlled by a PAR (J5D) and the other three do not currently operate with a PAR (the two PARs at Lambton are in bypass and the replacement B3N PAR has been ordered).
- There are PARs on the IMO-MP interface and the IMO-MH interface. Both of these interfaces are operated such that schedule flow equals actual flow and do not contribute to circulation flow around Lake Erie.

Except for the PARs on the IMO-MP interface and the IMO-MH interface, most PARs are not operated to control flows such that schedule flow equals actual flow across an interface. If they were able to control schedule flow equals actual flow, there would be no circulation flow. However, most PARs were installed to address a very specific condition and are usually successful managing that one specific condition. As conditions change such that managing that one specific condition is no longer needed, it is very difficult to have the PARs operate in a manner that is different than their design.

Take for example the PARs on the PJM-NY interface, the Ramapo PAR is designed to deliver power from PJM to NY via the Branchburg-Ramapo 500 KV line. The PARs at Waldwick, Linden and Hudson are designed to deliver 1000 MW into the New York City grid via the New Jersey transmission system on a continuous around-the-clock basis. These PARs are very effective at meeting their design objective. However, when system conditions change such that the design objective is not needed such as a reduced PJM to NY schedule or even a schedule flowing in the reverse direction, it is difficult to redirect the PARs in a different manner. While the PARs have taps that can reduce the flow bias, there are limits to how many tap movements can be made during the day. There are also dead-bands used such that there is a delay between a change in system conditions and when the PARs recognize the change and move accordingly. The PARs also have a limited number of tap points that restrict the range of their operation. While they can be taken off-line to move a fixed tap to give them more range, this is normally not done for daily cycles when a return to the fix tap position would be needed for other parts of the day.

Diagram 22 plots of flows on the Branchburg-Ramapo 500KV line versus the circulation flow measured on the NY-PJM interface using hourly data points from 2006. A positive value indicates counter-clockwise circulation and a negative value indicates clockwise circulation. The majority of the points appear in the first quadrant. This means that when Branchburg-Ramapo had a positive flow, there were counter-clockwise circulation flows that got as high as 1,800 MW. As noted in the ITC review of dates and times, during times of high flows across the Michigan-Ontario interface, there are large schedules from PJM to NY. This matches the bias of the Ramapo PAR and there are small circulation flows (these would be points close to zero on the y axis). Small schedules from PJM to NY or schedules in the opposite direction are scheduled to flow against the bias of the Ramapo PAR resulting in high counter-clockwise circulation flows (these would be positive points further away from zero on the y-axis). The key to this analysis is that the majority of the points on this scatter diagram show a positive flow on Branchburg-Ramapo indicating a natural bias flowing from PJM to NY.

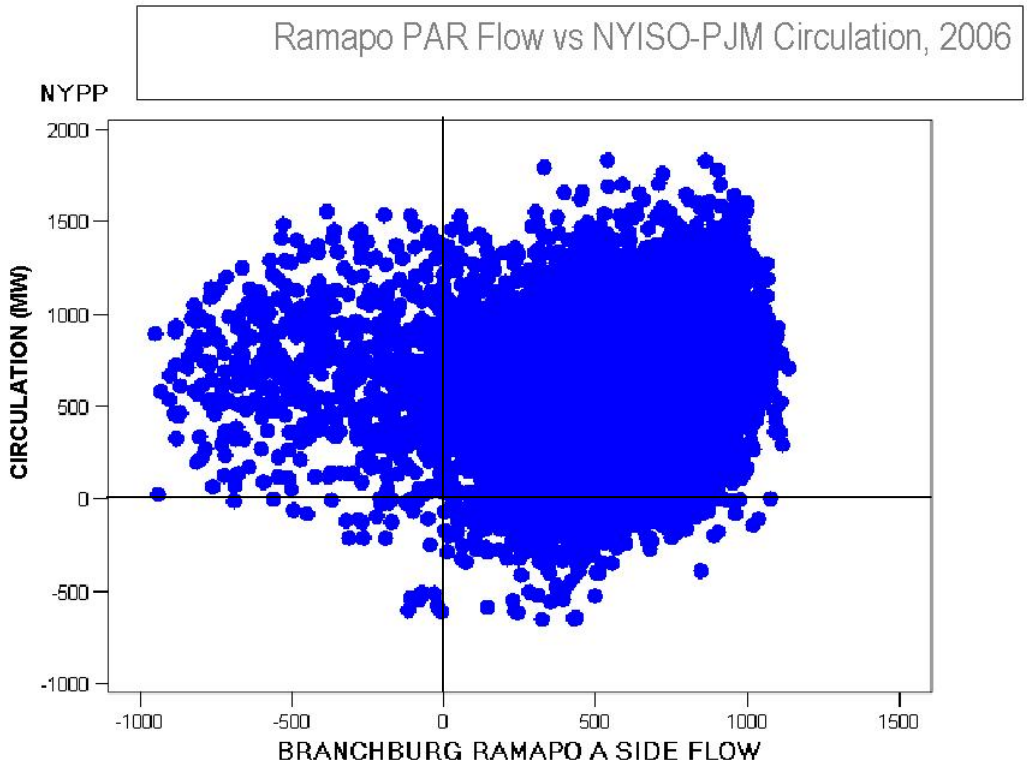

Diagram 22

Diagram 23 shows the impact of the Ramapo PAR flow as a contour plot of average circulation at Ramapo PAR vs. NYISO-PJM schedule. Similar to the previous diagram, this uses hourly values from 2006. This diagram shows high PJM to NY schedules results in small Lake Erie circulation flows (left side of second quadrant). However, as PJM to NY schedules are reduced to a point where schedules are small or even in the opposite direction coincident with high Branchburg-Ramapo flows results in very high Lake Erie circulation flows (first quadrant and right side of second quadrant).

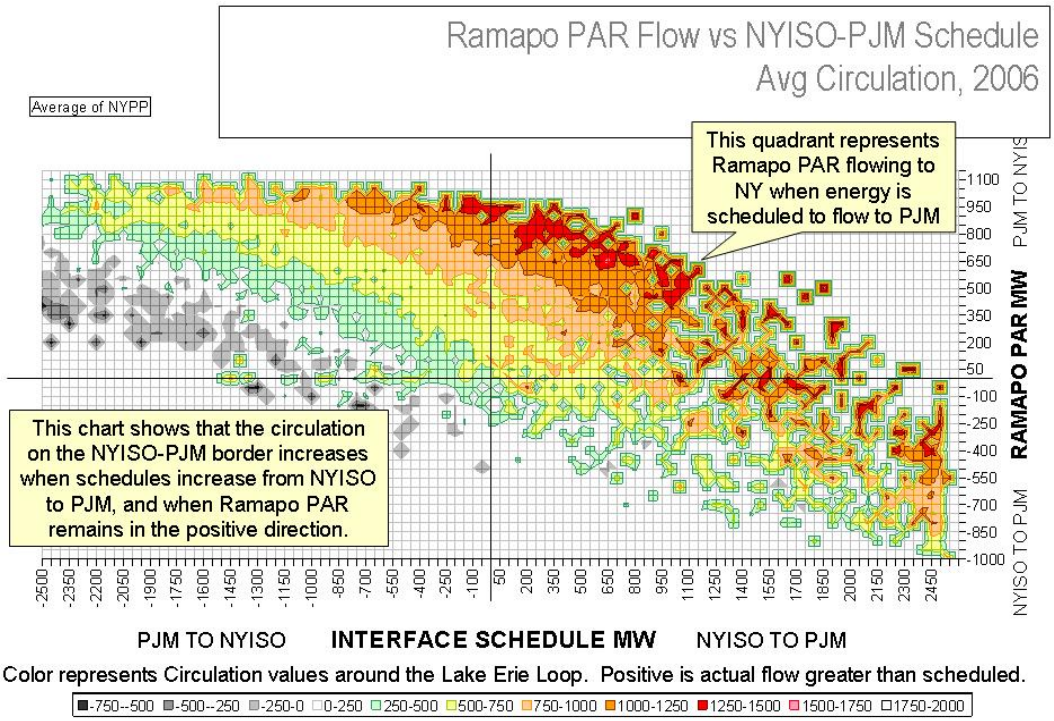

Diagram 23

While this is not an exhaustive review of the PAR operations, it shows a strong correlation between the operation of the PARs and circulation flows has been found. Several other variables were plotted on separate contour plots to see if there was a correlation with these other variables.

- IMO-NY schedules (see Diagram 24)
- MECS-IMO schedules (see Diagram 25)
- PJM-Midwest ISO schedules (see Diagram 26)

Of these three, only the high PJM to Midwest ISO schedules showed a correlation with high Lake Erie circulation flow. This may be due to times when they are high schedules from NY to PJM may also occur when there are high schedules from PJM to Midwest ISO.

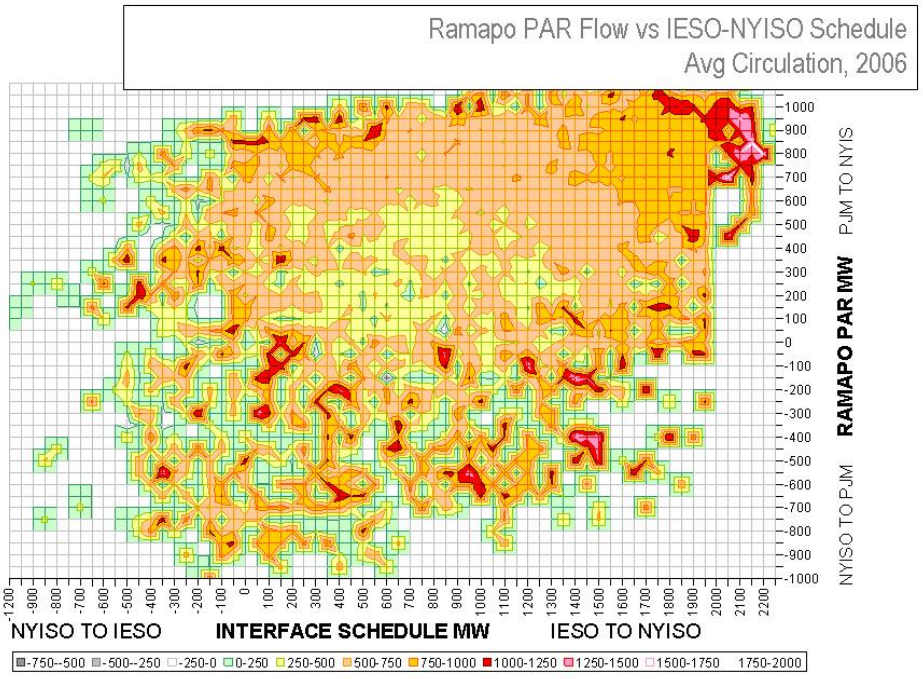

Diagram 24

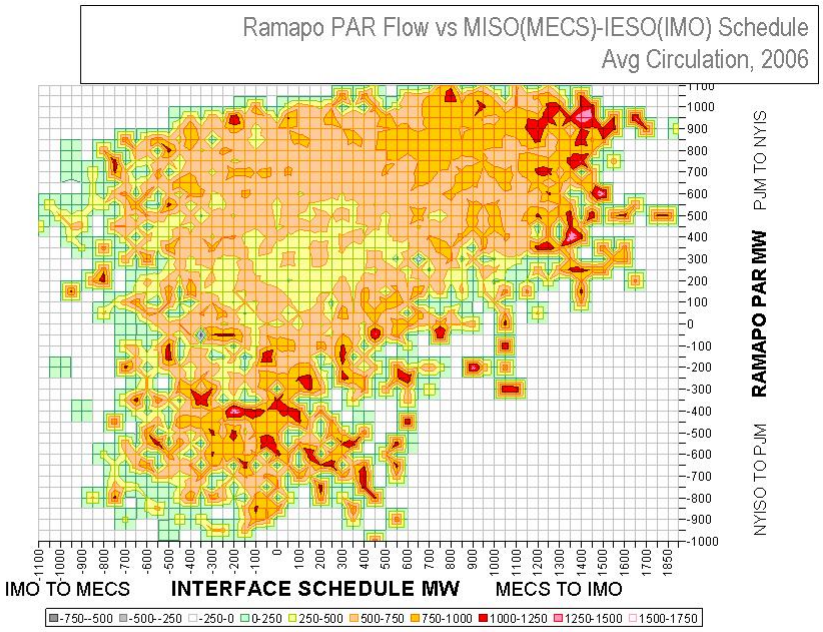

Diagram 25

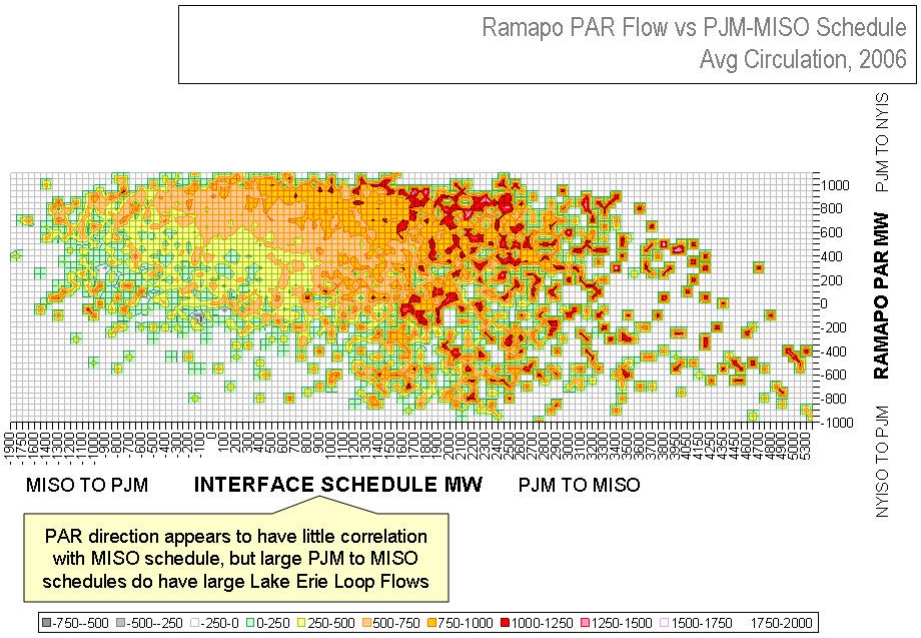

Diagram 26

Further review of the PAR operation on the PJM-NY interface is needed to verify the correlation with circulation flow. It should also look at how the Ramapo PAR is coordinated with the operation of the PARs at Waldwick station (JK), at Linden and Hudson stations (ABC). A similar analysis should be made of the St. Lawrence PAR and the one regulating PAR on the MECS-IMO interface (J5D). Along with the review of the existing PARs, a review should be made of the future operation of the PARs at Lambton and B3N on the MECS-IMO interface. This future PAR operation is designed to operate the MECS-IMO interface such that schedule flow equals actual flow but will likely experience all of the same operating issues as the other PARs which means there will be numerous occasions when the PARs are not able to operate such that schedule equals actual.

Components of Lake Erie Circulation Flows

The last part of the study focused on the Lake Erie circulation flows and attempted to identify the components of the circulation flows. Starting with December 2006 and January 2007 are plots of circulation flows at each of the three interface points between the four markets (MECS to IMO, IMO to NY and NY to PJM). Tag impacts contribute to circulation and there are generation-to-load impacts that contribute to circulation. Starting with the generation-to-load impacts, Midwest ISO and PJM both report their real-time market flows to the IDC every 5 minutes. These market flows represent the impact of generators being used to serve load inside the market. They take into account tagged

transactions into and out of the market such that there is no double counting in the market flows.

The Midwest ISO and PJM market flows have been plotted at each of the three interfaces:

- MECS to IMO Circulation (see Diagram 27)
- IMO to NYISO Circulation (see Diagram 28)
- NYISO to PJM Circulation (see Diagram 29)

The PJM net market flows appear in the blue shaded area (the net of forward market flow and reverse market flow). They range from 200 MW to 500 MW in a clockwise direction and are relatively stable compared to Lake Erie circulation flow. The Midwest ISO net market flows appear in the red shaded area (the net of forward market flow and reverse market flow). They range from 100 MW to 250 MW in a counter-clockwise direction and are relatively stable compared to Lake Erie circulation flow. For these two months, the PJM market flows are in a direction opposite to the predominant circulation flows and help to reduce the magnitude of the circulation flows. Midwest ISO market flows, on the other hand, are in the same direction to the predominant circulation flows but do not represent the major component of these circulation flows.

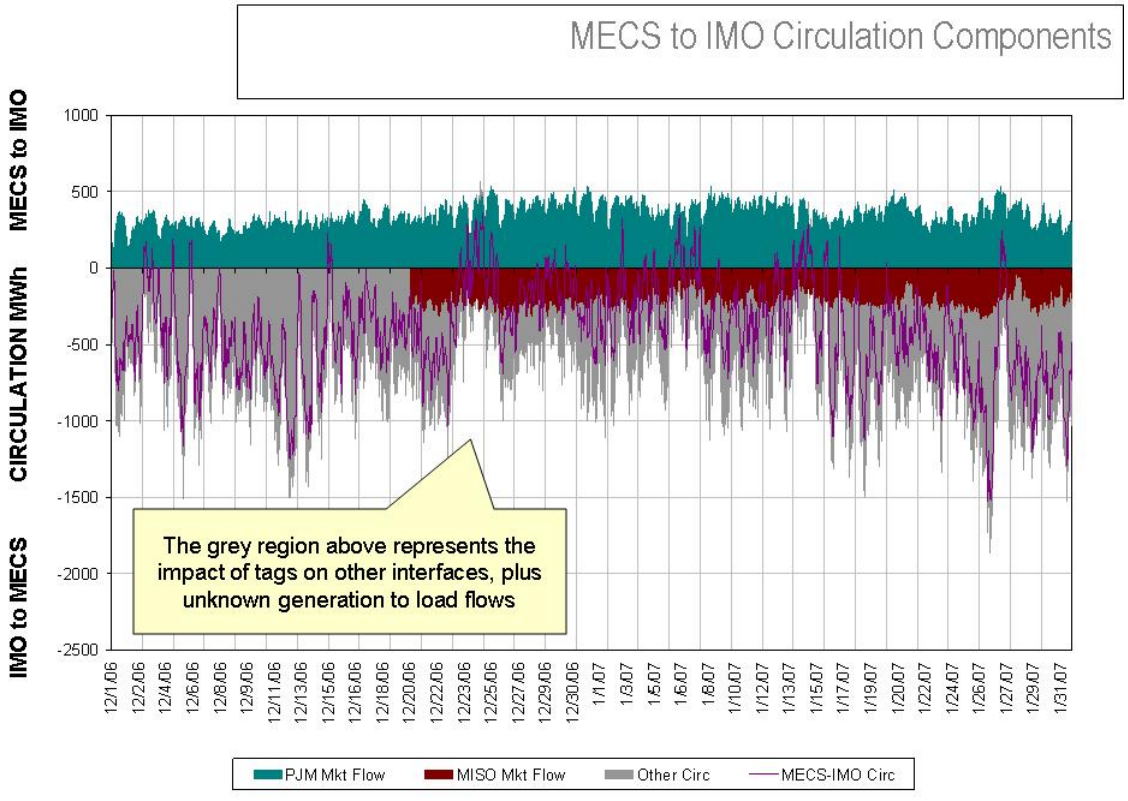

Diagram 27

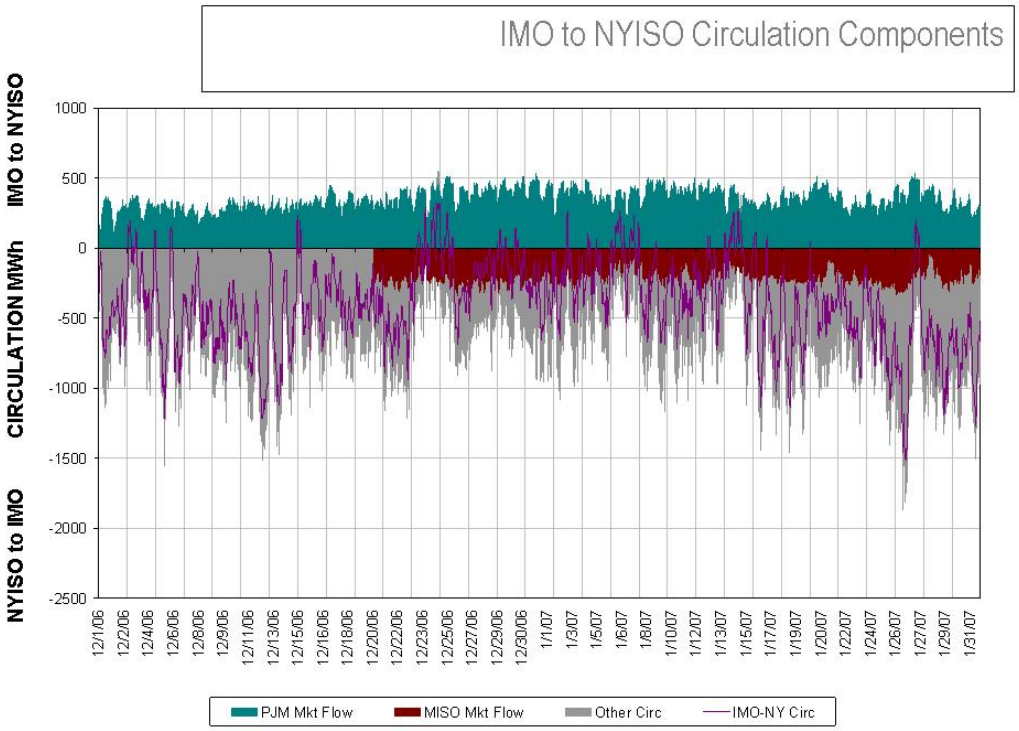

Diagram 28

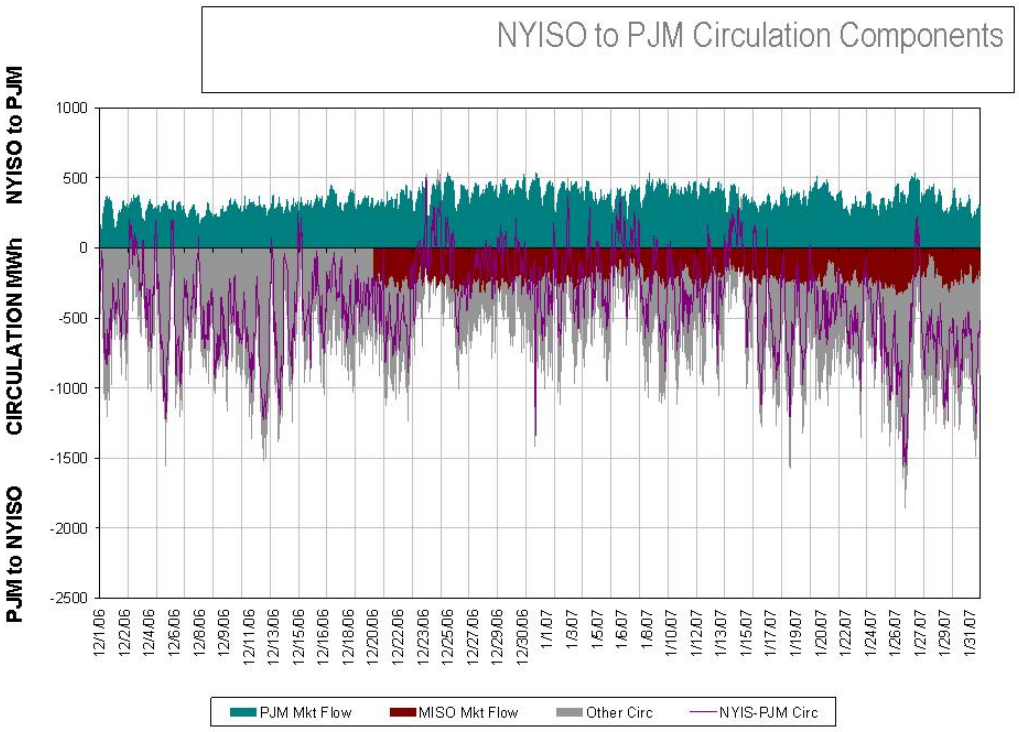

Diagram 29

The gray shaded area is obtained by subtracting Midwest ISO and PJM market flows from the Lake Erie circulation flows. The Midwest ISO made a fix to its market flow calculator on December 20, 2006. Prior to this date, market flows on multiple monitored element flowgates were being overstated in the IDC. The overstated Midwest ISO market flows are not shown on the plot because it would give a misleading impression of the other contributors to circulation flows in the gray shaded area. As presented in the diagram, the gray shaded area includes Midwest ISO market flows as well as other contributors on December 1 through December 20. The gray shaded area only includes other contributors in the remaining days of the plot.

A key question is what are the other contributors to the Lake Erie circulation flows (i.e., what makes up the gray shaded area)? Similar to Midwest ISO and PJM, both IESO and NYISO operate markets where market generators are being used to serve market load. Unlike Midwest ISO and PJM, neither IESO nor NYISO compute their market flows on flowgates (including the interfaces between the markets) and there are no market flows being reported to the IDC from these two markets. While there have been no attempts to quantify the NYISO market flows, Midwest ISO made an off-line analysis of IESO market flows that looked at a number of days in 2006 and 2007. From this analysis, Midwest ISO found the IESO net market flows (the net of the forward market flow and the reverse market flow) range from 125 MW to 275 MW in a counter-clockwise direction. In the same off-line analysis, the PJM net market flow ranged from 250 MW to 475 MW in a clockwise direction and the Midwest ISO net market flow ranged from 150 MW to 250 MW in a counter-clockwise direction. The PJM and Midwest ISO findings in the off-line analysis are consistent with the net market flows reported to the IDC in real-time.

Besides the market flows from the IESO market and the NYISO market, another contributor to the gray shaded area is the impact of tags. By definition, the circulation flow is the difference between schedule flow and actual flow. The schedule flow assumes that 100% of the tags scheduled across an interface appear on that interface and 0% of the tags not schedule across an interface appear on that interface. In reality, less than 100% of the schedule tags and some amount greater than 0% of non-scheduled tags appear on the interface. If the PARs on an interface were successful at maintaining schedule flow equals actual flow, there would be no circulation flow and 100% of the scheduled tags would flow across the interface and 0% of the unscheduled tags would flow across the interface. As stated previously, it is very difficult to operate PARs such that schedule flow equals actual flow and there is no circulation flow.

It is difficult to quantify the magnitude of the tag impacts that appear in the gray shaded area. While the IDC makes this type of calculation, it usually uses a threshold of 5% or greater impacts that are used for TLR purposes. You can apply a lower percentage in the IDC to see all impacts down to 0% in the forward and reverse directions. You would then net the two values together to get the net

impact of tags that are in the gray shaded area. While this kind of analysis can be made on a real-time basis by taking snapshots using the IDC, there is no ability to do this on an on-going basis and no ability to archive the information such that it could be used in a historical plot of December 2006 and January 2007 conditions.

Midwest ISO performed an analysis of tag impacts from February 5, 2007. Because of low temperature forecasts, Midwest ISO projected that it would experience seasonal peak loading conditions. In anticipation that there could be high circulation flows occurring coincident with the winter peak, Midwest ISO made arrangements to have an individual periodically take snapshots from the IDC of market flows and tag impacts down to 0% across the MECS-IMO interface. Impacts in both the forward and reverse directions were captured such that the net impacts of market flows and tags could be determined. Snapshots were taken at 9 am, 12 noon, 3 pm, 6 pm, and 9 pm. The market flow impacts available from the IDC are the combined Midwest ISO and PJM market flows reported to the IDC down to 0% in the forward and reverse direction. The tag impacts available from the IDC are all tags in the IDC that have either a positive response factor or a negative response factor down to 0%.

The snapshot showed a significant net tag impact (the sum of positive and negative impacts) in the counter-clockwise direction (from IMO to MECS) that ranged from 580 MW to 1,280 MW during the 5 hour period. This cannot be considered circulation flow because it includes both tags scheduled across the interface plus all other tags. The impacts of tags scheduled across the interface need to be removed to obtain the contribution of remaining tags to circulation flow on February 5, 2007 (part of the gray shaded area).

The snapshot also showed that net market flow impacts (the sum of the positive and negative impacts) were in a clockwise direction during 4 of the 5 hours and offset the counter-clockwise impacts of the tags. In the one remaining hour when the net market flows were in a counter-clockwise direction, they added a relatively small amount to the counter-clockwise impact of the tags (13 MW counter-clockwise impact from market flows compared to a 974 MW counter-clockwise impact from tags). In general, the magnitude of the net market flow impacts was much smaller than the magnitude of the net tag impacts. The net market flow impacts ranged from 13 MW counter-clockwise to 179 MW clockwise during the 5 hours while the net tag impacts ranged from 580 MW counter-clockwise to 1,280 MW counter-clockwise during the 5 hours.

There are several observations that can be made based on the snapshots taken from the IDC on February 5, 2007:

- It supports the earlier comment that the Midwest ISO and PJM market flows tend to be in different directions with PJM net market flows in a clockwise direction of 200 MW to 500 MW and Midwest SO net market flows in a counter-clockwise direction of 100 MW to 250 MW. When

combined, the net market flows of the two RTOs are in the 100 MW to 250 MW range in the clockwise direction. This is the equivalent of combining the blue shaded area and the red shaded area from the December 2006 and January 2007 diagrams. The tags have much larger net impacts than the market flows and the net tag impacts are in a counter-clockwise direction (increasing the amount of circulation flows) while the net market flow impacts are in a clockwise direction (decreasing the amount of circulation flows).

- In order to perform this analysis of tag and market flow impacts on the MECS-IMO interface, Midwest ISO had to make arrangements in advance for an individual to take snapshots from the IDC during different time periods during the day. This type of data is needed in order to do an analysis of the tag impacts, market flow impacts and other impacts that are in the gray shaded area. It is not practical for individuals to periodically take snapshots from the IDC when this data could be archived by the IDC for after-the-fact reviews.
- The IDC could be enhanced such that it distinguishes between tags that are scheduled across an interface versus those that have other impacts on the same interface. This would directly determine the circulation component of tags without doing additional calculations (see Diagram 30).

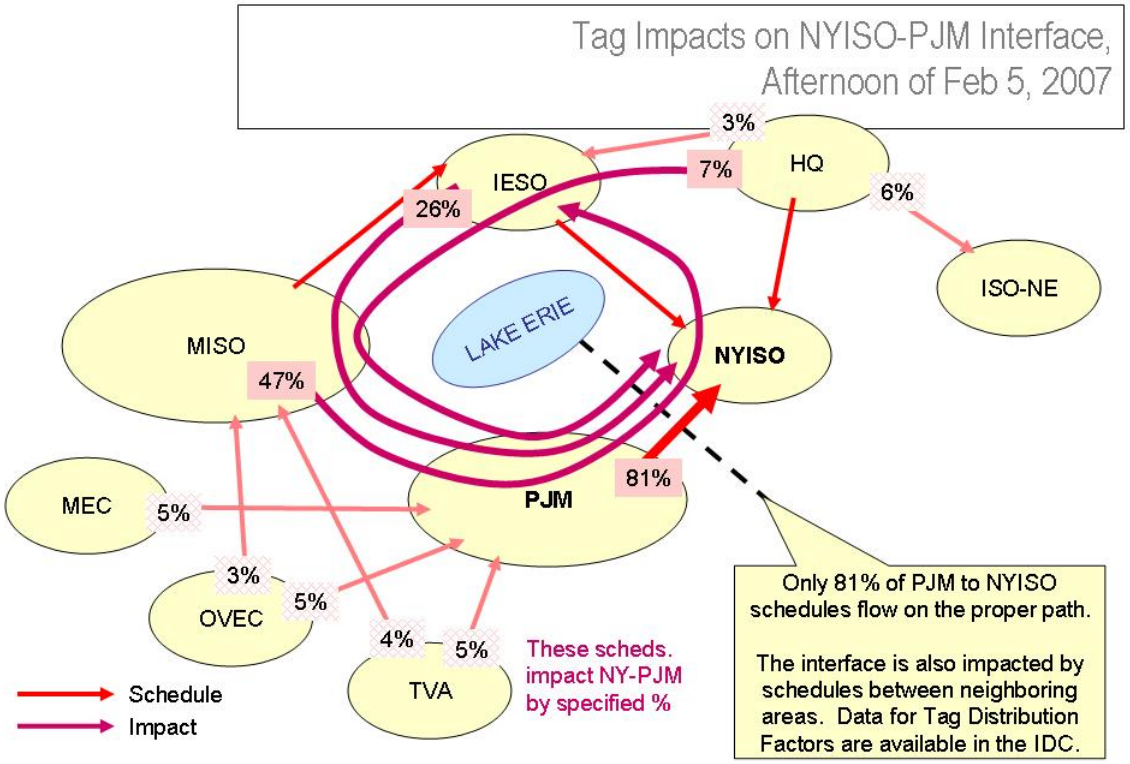

Diagram 30

A recommendation from this report is that data archive capability be added to the IDC such that historical information on tag impacts, market flow impacts and generation-to-load impacts is captured for all flowgates in the IDC and is available to make the type of historical reviews that were performed in this circulation flow study.

The operation of the PARs on the PJM-NY interface contributes to circulation flows. The PARs themselves do not create flows. They alter flows that absent the PARs would have followed a different electrical path. Consequently, the operation of the PARs is causing actual flows to differ from scheduled transactions and the generation-to-load flows from inside the markets to follow electrically different paths than if the PARs were not there.

Similar to Midwest ISO and PJM, there are IESO and NYISO market flows that contribute to Lake Erie circulation flows (make up part of the gray area). These market flows are influenced by the operation of the PARs. In some cases, the IESO and NYISO market flows will increase the circulation flows and in other cases, the IESO and NYISO market flows will decrease the circulation flows due to the operation of the PARs. Under ideal conditions, the PARs would be operated such that they always minimize circulation flows and there would be no need for this kind of study. As stated previously, there are operating limitations on how much power can be controlled by a PAR, there are restrictions on the number of tap movements allowed per day and there are dead bands used to delay the response of the PAR. All of these real-world issues prevent operating the PARs under ideal conditions.

The PARs are going to continue to be used to manage the specific condition they were installed to manage and are not able to operate continuously under ideal conditions. It is important that the IESO and NYISO contributions to circulation flows be identified in the IDC and be subject to the same type of relief obligations as the Midwest ISO and PJM. Under this recommendation, the PARS are allowed to operate in accordance with their design requirements and contractual obligations. However, the impact of PAR operation to the contributions to Lake Erie loop flow needs to be identified so that everyone joins in managing these flows during periods when congestion exists.

Besides the impacts of the market flows from the IESO and NYISO markets and the impact of tags, there are other contributors to the gray shaded area. However, these other contributors will be minor compared to the ones previously described.

Summary

Unscheduled flow around the Lake Erie Loop is an issue that has existed for many years, affecting almost all organizations in the northeast region of the Eastern Interconnection. For an interface between two control areas, the unscheduled flow's root cause is that the transmission distribution of scheduled interchange of energy is not equal to the contract path of the transactions that are expected to flow across the interface. Additionally, there are impacts caused by a control area's generation serving its load as the transmission distribution of energy routes the energy through a neighboring system.

Itemized Contributions to Lake Erie Circulation Flow

Market Flow Impacts

- PJM Generation-to-Load Flow: Calculated by CMP, quantified as a general clockwise impact on the Lake Erie Loop
- Midwest ISO Generation-to-Load Flow: Calculated by CMP, quantified as a general counter-clockwise impact on the Lake Erie Loop
- IESO Generation-to-Load Flow: Not currently calculated.
- NYISO Generation-to-Load Flow: Not currently calculated.

Each control area's generation serves its internal load via an economic dispatch, and the distribution from generation-to-load can cross the control area's boundaries, traveling to its neighbors and back in again. A Congestion Management Process provides a mechanism for a market control area to calculate its real-time impacts on its neighbors, report these impacts to the IDC, and be subject to relief obligations during congestion.

Transaction (Tag) Impacts

- Area-to-Area transactions: Data is difficult to capture because information is not readily available for querying from the IDC.
- Midwest ISO was able to capture five hours of IDC data over the Winter Peak in February 2007. The data shows a large variation in impacts across the flowgates from hour to hour. The data also shows that for the five hours studied, the net tag impacts created a counter-clockwise impact on the Lake Erie Loop.

A control area economically dispatches its generation to over-generate or under-generate relative to its native load to provide scheduled energy requested by the market. Depending on the real-time configuration of the transmission system, the energy distribution can impact neighboring areas both near and far. The IDC

is the industry recognized source of real-time impact calculations, but the IDC does not archive the data for future review.

Operations of Phase Shifting Transformers

- Present PJM-NYISO PAR Operations on PSE&G-ConEd border: PJM and NYISO have committed to review the impact of current PAR operations, and if operation changes should be required. Our limited studies have shown some periods of correlation, but more study is required.
- Present NYISO-IESO Par Operations on St. Lawrence PARs. Additional studies are needed to assess the impact of these PARs on Lake Erie loop flows.
- Future Midwest ISO-IESO PAR Operations on ITC-IESO border:

A PAR is specifically designed to alter the impedance of the bulk power transmission system to control flows in a region of the grid, thus PAR operation can impact loop flow by adjusting transmission distribution. There are several PAR devices scattered around the northeast, and many have complicated agreements that govern their use.

Recommendations / Future Steps

Four party talks between Midwest ISO, PJM, NYISO and IESO have resulted in some very positive discussions on actions that the parties can accomplish over the next several years relating to mitigating loop flow.

Midwest ISO, PJM, NYISO and IESO recommend the commissioning of the Michigan-Ontario PARs as soon as possible to mitigate the loop flow around the Lake Erie Loop.

- Some regulation of the loop flow using the PARs would begin as soon as the asset owners agree and operating procedures on the second and third devices.
- On an interim basis (prior to the replacement of the B3N PAR), the PARs at Lambton will operate in a regulation mode either with or without B3N line in service (whichever provides the higher transfer capability).
- On a long term basis (once the B3N PAR has been replaced), all four Ontario-Michigan PARs will operate in regulation mode.
- The four parties will continue to monitor the Lake Erie Loop Flow prior to, and following, the operation of the Michigan-Ontario PARs to measure how successful they are at maintaining schedule equals actual.
- PJM and NYISO will commit to review NY/PJM interface PAR operations to assess contributions to Lake Erie Loop Flow.

- NYISO and IESO will commit to review the St. Lawrence PAR operations to assess contributions to Lake Erie Loop Flow.
- The four parties will develop a comprehensive plan on the operation of the Michigan-Ontario and NYISO/PJM PARS to control loop flows around Lake Erie.

Prior transmission studies have shown that using three PARs would control up to 400 MW of flow along the MECS-IMO interface. With all four PARs in service, IESO could provide up to 600 MW of flow control. Based on observed loop flow magnitudes throughout 2006, this level of PAR control on the MECS-IMO interface could control loop flow to zero for over half of the hours of Lake Erie loop flow. In practice, however, the net loop flow effects of the PAR operations would be limited by the yet to be finalized control agreements set between Hydro One, IESO, ITC and Midwest ISO, specifically the number of controlling tap moves per day, dead-bands to control, etc.

In summer 2006, PJM and NYISO implemented a new set of procedures for controlling flows on the PSE&G/ConEd wheel that de-emphasized control of the Branchburg-Ramapo 500kV line and focused on creating targets for energy entering the JK PARs and leaving on the ABC PARs. While the NYIS-PJM schedule can drastically change hour-to-hour, dispatch operations is reluctant to move the Ramapo PAR tap settings because of how it impacts the PSE&G/ConEd wheel and constraints around northern New Jersey and New York City.

Utilizing the PARs could seriously lessen what is currently considered large counter-clockwise circulation, but PAR operation is not the sole solution to mitigating the impacts of loop flow.

IESO and NYISO should adopt a Congestion Management Process whereby they report their market flows to the IDC and participate with Midwest ISO and PJM to manage circulation flows around Lake Erie when congestion occurs.

While it is believed that the hardware solution of implementing the MECS-IMO PARs will control much of the loop flows around the Lake Erie Loop, the hardware solution would not eliminate the causes of circulation. A Congestion Management Process, together with generation-to-load calculations, would allow each ISO to calculate their circulation impact on the Lake Erie Loop, and could enable market-to-market re-dispatch for flowgate control.

In practice, a Congestion Management Process allows a facility's owner to assess the impacts of the neighboring markets, and properly send signals to optimize economic re-dispatch. The Congestion Management Process is currently used to mitigate single facilities whose historical usage defines the

market-to-market compensation for overuse. The Congestion Management Process allows monitoring of interface-level impacts but mitigation still occurs on single facilities.

Midwest ISO, PJM, NYISO and IESO recommend creating an Energy Schedule Tag Archive that contains tag impacts, market flow impacts, and generation to load impacts for flowgates contained within the IDC. This archive will provide a historical record to aid in additional loop flow research.

- PJM will submit the request on the behalf of the four parties to the IDC Working Group.
- The initial focus will be to establish an archive at OATI for data currently generated in real-time.

OATI's Interchange Distribution Calculator is the industry standard for calculating transaction impacts on flowgates across the Eastern Interconnection, and is the coordinator of all Transmission Loading Relief curtailments. Tagged transaction distribution is a major component of circulation, and power flow models have historically been used to calculate the distribution impacts of transactions between areas. The four parties will use the TDF / Transaction Impact archive to determine trends in schedule impacts.