NEW YORK INDEPENDENT SYSTEM OPERATOR
10 Krey Boulevard ♦ Rensselaer, NY 12144

August 26, 2011

ELECTRONICALLY SUBMITTED

Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Re: New York Independent System Operator, Inc.'s Report on Broader Regional Markets; Long-Term Solutions to Lake Erie Loop Flow; Docket No. ER08-1281-___.

Dear Secretary Bose:

In its January 12, 2010 filing in the above Docket, the New York Independent System Operator, Inc. ("NYISO") informed the Commission that it, PJM Interconnection, LLC ("PJM"), the Midwest Independent Transmission System Operator, Inc. ("MISO"), and the Ontario Independent Electricity System Operator ("IESO") (collectively, the "Lake Erie ISOs/RTOs"), committed to perform a regional study to review the operating characteristics of Phase Angle Regulators ("PARs") and other control devices located around Lake Erie to study the potential reliability and market impacts of better coordinated operation of these devices. In accordance with this commitment, the NYISO hereby submits on behalf of the Lake Erie ISOs/RTOs the first *Regional Power Control Device Coordination Study Final Report* ("Report"). A second *Regional Power Control Device Coordination Study* ("Second Study") will be prepared by the Lake Erie ISOs/RTOs after the Ontario-Michigan PARs enter service and the ISOs/ RTOs are able to gather data regarding their operation in conjunction with the various devices that are already in service. The ISOs/RTOs anticipate that the Second Study will be commenced after the ISOs/ RTOs gain sufficient operational experience of the PARs and a report will be filed with the Commission upon completion.

While the NYISO is responsible for submitting this Report to the Commission, the contents of the Report were developed through collaboration between and among all of the Lake Erie ISOs/RTOs. The NYISO hopes and expects that the cooperative effort that has permitted the ISOs/ RTOs to develop the Report will continue until the Second Study is complete.

I. Documents Submitted

1. This filing letter; and

2. The *Regional Power Control Device Coordination Study, Final Report*, prepared by Midwest ISO, PJM, IESO and NYISO ("Attachment I").

II. Discussion

The Regional Power Control Device Coordination study group included participants from each of the four Lake Erie ISOs/RTOs. The scope of the study was to review the operating characteristics of the PARs as well as other control devices located in the control areas that surround Lake Erie to study the potential reliability and market impacts of better coordinated operation of these devices. The Report also evaluated the correlation between scheduled interchange between the Lake Erie ISOs/RTOs and Lake Erie circulating power flows ("LEC"). The Regional Power Control Device Coordination Study has been divided into two parts. The initial Report, described below, is submitted with this letter. The intended purpose and scope of the Second Report is also described below, and will be submitted upon its completion.

The Report concludes (1) a correlation between PAR operation and LEC can, under some circumstances, exist, and (2) a significant correlation was found between scheduled interchange among the Lake Erie ISOs/RTOs and LEC. The Report cautions that a strong observed correlation between variables does not necessarily imply that a causal relationship exists between those variables.

1. Regional Power Control Device Coordination Study

The first Regional Power Control Device Coordination Study considered a range of scenarios in determining where correlations might be identified between Lake Erie loop flow and the operations of the Ramapo PARs, the St. Lawrence PARs or the J5D PAR. The analysis also evaluated the correlations of PJM-NYISO, IESO-MISO, IESO-NYISO and PJM-MISO Scheduled Interchange versus Lake Erie loop flow. The correlation results produced in the first component of the study process and described in the attached Report will be utilized as a potential reference in the Second Study, which will not commence until all of the PARs at the Ontario/Michigan interface are in service and are being operated in a coordinated manner.

While performing the studies that are described in the attached Report, the Lake Erie ISOs/RTOs study group recognized that it is difficult to isolate the effect of specific PARs on Lake Erie loop flow in the real-time dynamic system, and that PARs are only one component of managing Lake Erie loop flow. System topology, generation commitment, and the level of scheduled interchange all impact Lake Erie loop flow.

2. Part 2 of the Regional Power Control Device Coordination Study

The Second Regional Power Control Device Coordination Study will be performed after the Ontario-Michigan PARs enter service and the Lake Erie ISOs/RTOs are able to gather data regarding their operation and gain sufficient operational experience. The Second Study will use an empirical analysis to evaluate PAR impacts on LEC and the interaction of tap movements between PARs. The Second Study analysis will be documented in a report of findings that the NYISO anticipates filing with the Commission for informational purposes.

III. Service

The NYISO will send an electronic link to this filing to the official representative of each of its customers, to each participant on its stakeholder committees, to the New York Public Service Commission, to all parties listed on the Commission's official service list in Docket No. ER08-1281-000 and to the New Jersey Board of Public Utilities. In addition, the complete filing will be posted on the NYISO's website at www.nyiso.com.

IV. Conclusion

The NYISO submits the attached report for informational purposes.

Respectfully submitted,

/s/ *Alex M. Schnell*

Alex M. Schnell
James H. Sweeney
New York Independent System Operator, Inc.
10 Krey Boulevard
Rensselaer, NY 12144

CERTIFICATE OF SERVICE

I hereby certify that I have this day served the foregoing document upon each person designated on the official service lists compiled by the Secretary in this proceeding in accordance with the requirements of Rule 2010 of the Rules of Practice and Procedure, 18 C.F.R. § 385.2010.

Dated at Rensselaer, New York this 26 day of August, 2011.

[s] Mohsana Akter
Mohsana Akter
Regulatory Affairs
New York Independent System Operator, Inc.
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Attachment I

Broader Regional Markets,
Regional Power Control Device Coordination Study
(IESO, MISO, NYISO, PJM)

June 1, 2011

Regional Power Control Device Coordination Study

Final Report

For Public Distribution

(IESO, MISO, NYISO, PJM)

6/1/2011

Disclaimer: Controllable devices are subject to contractual, safety, regulatory and statutory requirements, as well as design and equipment limitations. The operations of the controllable devices described and analyzed in the report reflect known or intended operations as of the issuing of this report. As noted, some devices included in the report are still pending final contractual, regulatory, and statutory requirements.

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Executive Summary

Study Overview

The Regional Power Control Device Coordination study group is comprised of participants from four parties (IESO, MISO, NYISO, and PJM). As identified in **Appendix G - Scope of Regional Power Control Device Coordination Study**, the scope of the study was to review the operating characteristics of Phase Angle Regulators (PARs) as well as other devices. In addition, the study's intent was to identify reliability and market impacts of PARs or other controllable devices which may have the ability to affect flows surrounding Lake Erie. Upon completion, the study would determine how these devices could be coordinated in such a manner to control Lake Erie Circulation (LEC) flow. The four parties (IESO, MISO, NYISO, and PJM) would then develop operating guide recommendations to reduce the LEC using the controllable devices identified by the study.

To determine if such coordination would be possible, the group evaluated which PARs would be investigated for impacts on the LEC. Using a template, the study group gathered and reviewed information regarding these PARs and their operations. The group used this information to identify operating restrictions for the devices that may prevent coordination of device operations. The group also analyzed historical market data to identify correlation between flows associated with LEC and flows on PARs.

The study group recognizes that PARs are only one component of LEC. System topology, generation commitment, and the level of scheduled interchange also affect LEC. The study group also recognizes the interdependency between system topology, generation commitment, level of scheduled interchange, and the ability to adjust PARs to operate to existing procedures or to reduce LEC.

Conclusions

An impact between PAR operations and LEC can, under certain circumstances, exist between some of the PARS surrounding Lake Erie.

The study group considered a range of scenarios in determining where significant correlations might exist between LEC and historic operation of area PARS. Scenarios associated with the Ramapo PAR (5018 line) addressed the direction of scheduled interface flows between PJM and NYISO, the direction of target flow for the 5018 line, and the Delta (Target – Actual) for the 5018 line. It was observed that when PJM-NYISO interchange and the 5018 target flow were in opposite directions there was a significant positive or strong positive correlation to LEC. Weak correlations were observed between LEC and St Lawrence and J5D PAR flows. Note: A strong observed correlation between variables does not necessarily imply that a causal relationship exists between those variables. However, a causal relationship could exist. Further data analysis is required to determine causal relationships.

The study group evaluated the correlations of PJM-NYISO, IESO-MISO, IESO-NYISO and PJM-MISO Scheduled Interchange versus LEC. The IESO-MISO Scheduled Interchange versus LEC indicated the highest level of correlation for the historical conditions evaluated. While none of these four scenarios show significant correlation by themselves, these Scheduled Interchanges do not occur in isolation from each other. By summing all of the average hourly interchanges on the four interfaces while taking into account the sign convention of Scheduled Interchange, a significant correlation was found between coincident scheduled interchanges and LEC.

Finally, the group agreed that future analysis would be required to analyze LEC after the installation of the Ontario - Michigan PARs in service. Two options exist: 1) reproduce analysis with similar scope to the 1999 MEN Study or 2) use an empirical analysis to evaluate PAR impact on LEC and the interaction of tap movements between the PARs. The study group reviewed the results and conclusions from the November 1999 Michigan-Ontario Phase Angle Regulator Study – An Interregional Perspective conducted by the MAAC-ECAR-NPCC (MEN) Study Committee. After review of the MEN study, the study group agreed that an empirical analysis would be the preferred option that would provide the most value in determining LEC correlations.

Summary of Devices

The PARs in operation around Lake Erie investigated to determine the greatest impact on the Lake Erie Circulation (LEC) include: PARs on the PJM and NYISO interface with ties at Waldwick, Linden and Hudson, and Ramapo; PARs on the NYISO and IESO interface at St. Lawrence; and PARs on the IESO and MISO interface that form the Ontario-Michigan interface ties.

Unlike most PARs, the PARs on the IESO-MP interface and IESO-MH interface operate to align schedule flows with actual flows across the interface. Most of the interface PARs were installed to address specific conditions, such as controlling local transmission constraints. Given such, there exist contractual and physical limitations in having a PAR operate in a manner that differs from its original design and purpose. In most instances, there is no flexibility to modify the objective function associated with operating the PARs.

The following is a summary of the devices the study group analyzed with respect to LEC:

- Ontario – Michigan PARs
- NYISO – PJM PARs
- St. Lawrence PARs

IESO-MISO PARs

The IESO-MISO PARs (Ontario-Michigan) were designed for the purpose of aligning the scheduled flows with the actual flows on the interface. The equipment provides a large number of tap positions, providing for finer granularity of control as well as the ability to adjust the tap positions hourly.

The Ontario-Michigan Interface consists of five PARs at three locations affecting the LEC. PARs on the Ontario-Michigan interface reside at Lambton (IESO), Keith (IESO), and Bunce Creek (MISO).

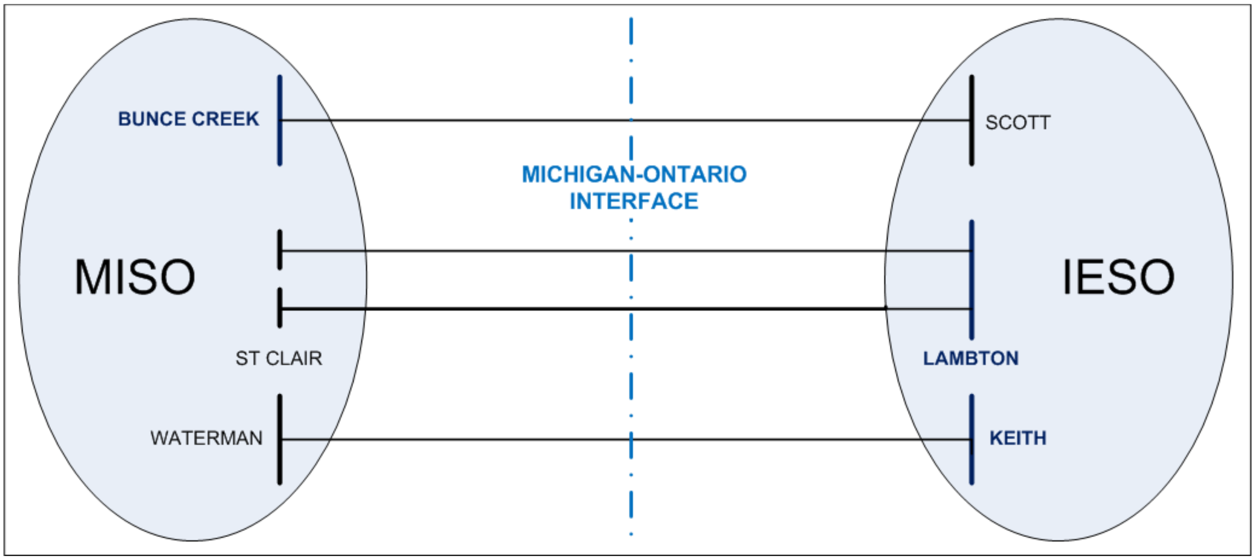


Figure 1. Ontario-Michigan Interface

Two PARs on the Ontario-Michigan interface reside at Lambton (IESO). Lambton PS4 is on 345kV circuit L4D from St. Clair (MISO) to Lambton (IESO). Lambton PS51 is located on 230kV circuit L51D.

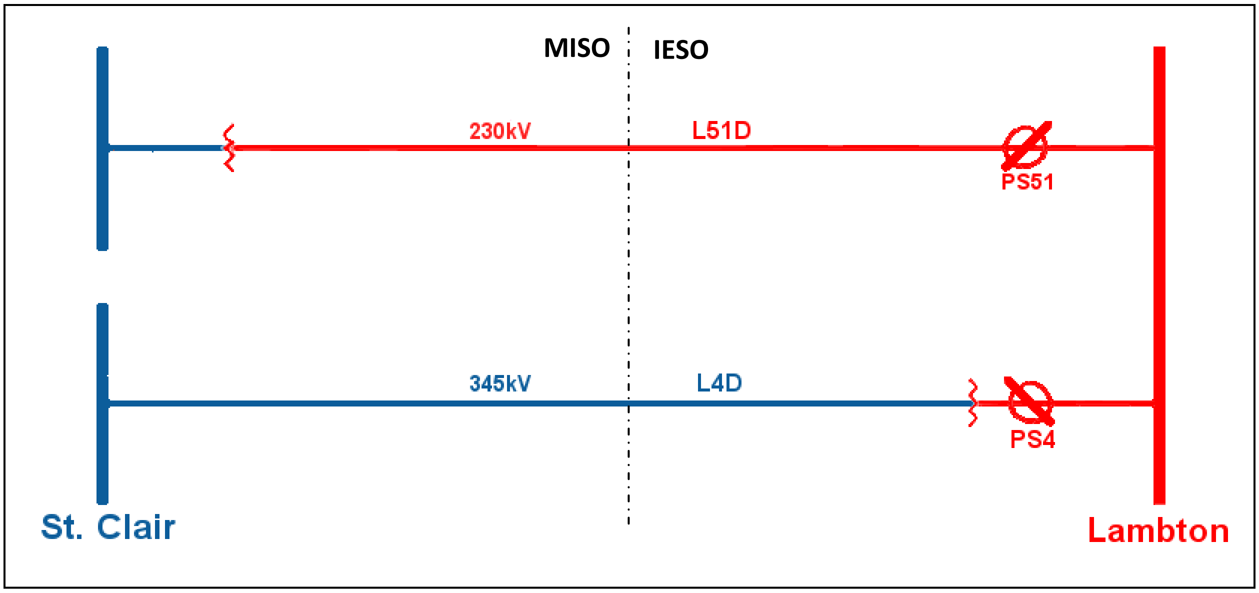


Figure 2. Lambton PS4 and PS51

One PAR is located at the Keith station in IESO. Keith PSR5 is located on the 230kV circuit J5D that runs from Waterman (MISO) to Keith (IESO).

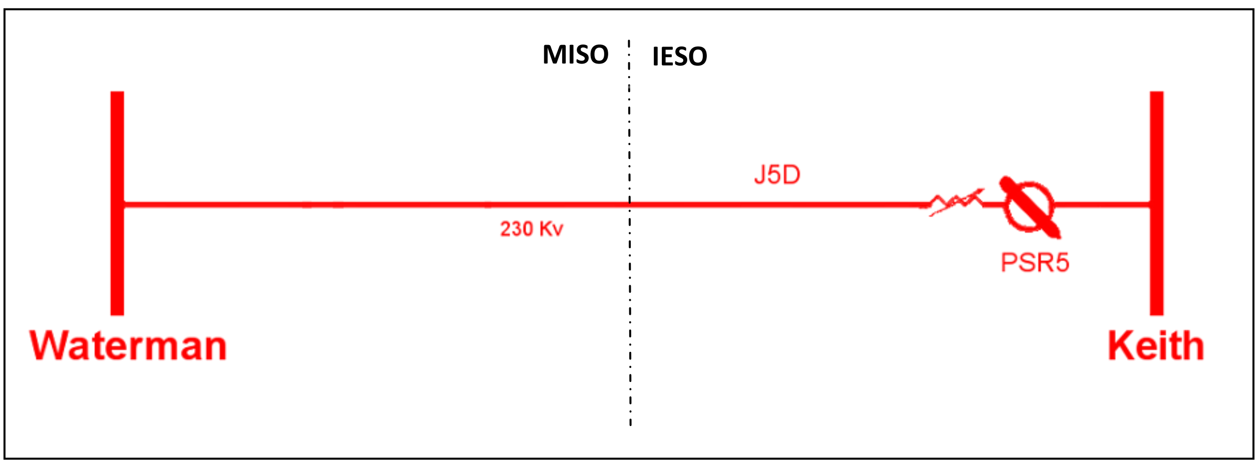


Figure 3. Keith PSR5

Two PARs are located at Bunce Creek (MISO). Bunce Creek PST1 & PST2 are both located on circuit B3N, a 230kV line from Bunce Creek (MISO) to Scott (IESO).

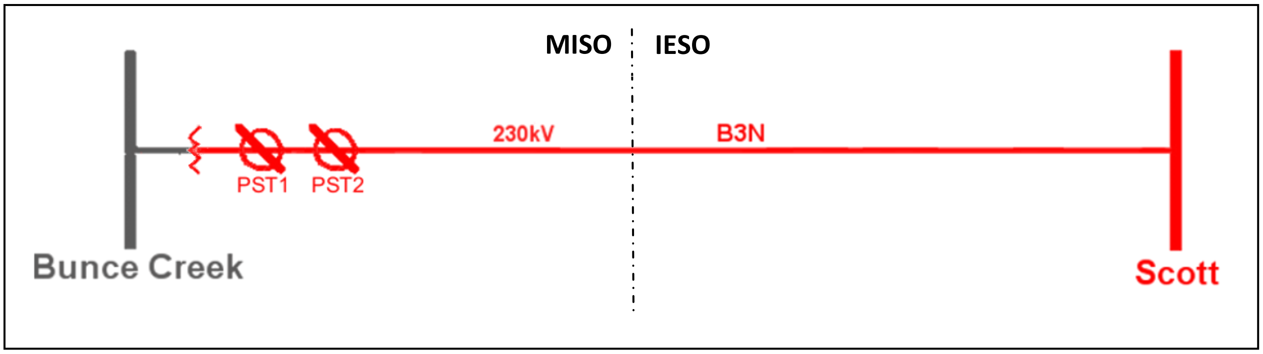


Figure 4. Bunce Creek PST1 & PST2

NYISO-PJM PARs

Eight phase shifters regulate the flow of power across the eastern AC ties between the NYISO and PJM systems:

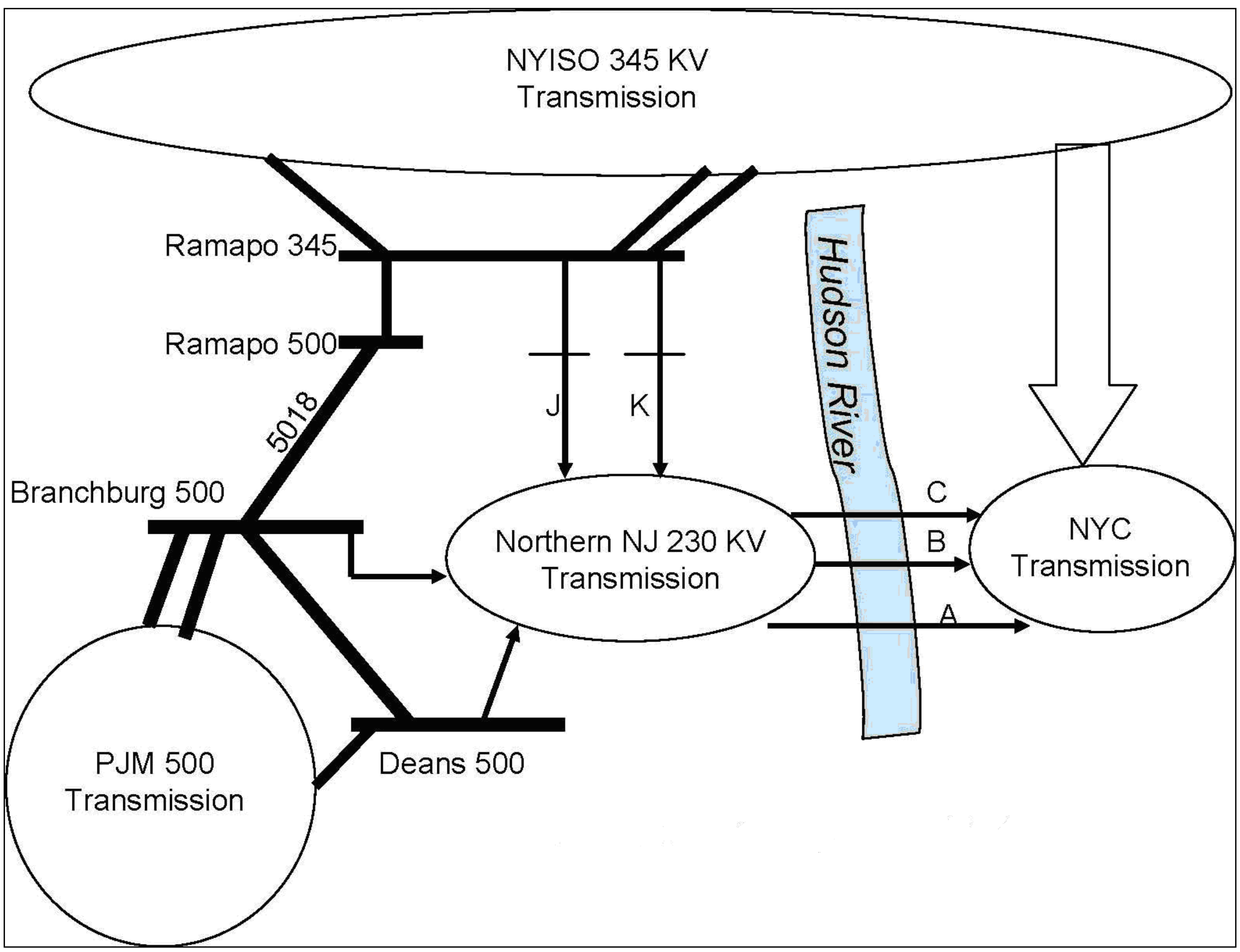


Figure 5. Ramapo ABCJK

Ramapo PS1 and PS2 are located within NYISO at the Ramapo station.

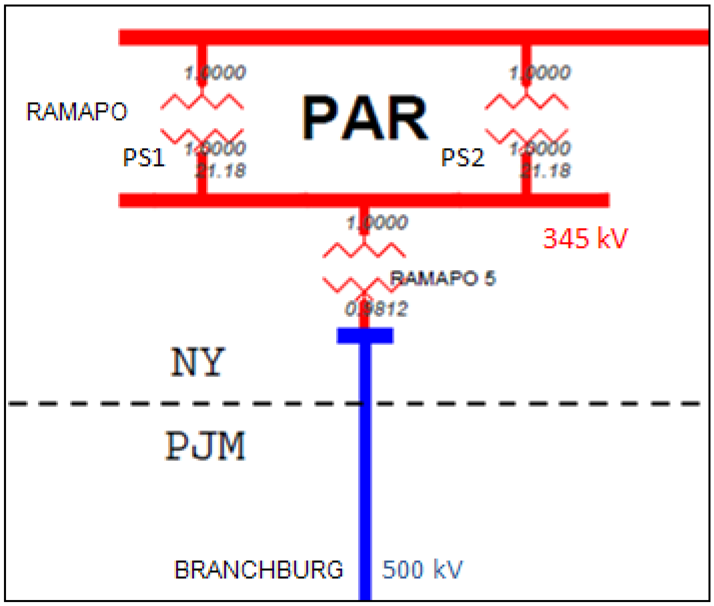


Figure 6. Ramapo PS1 & PS2

Waldwick PS1, PS2 and PS3 comprise the PARs at the Waldwick station located within PJM.

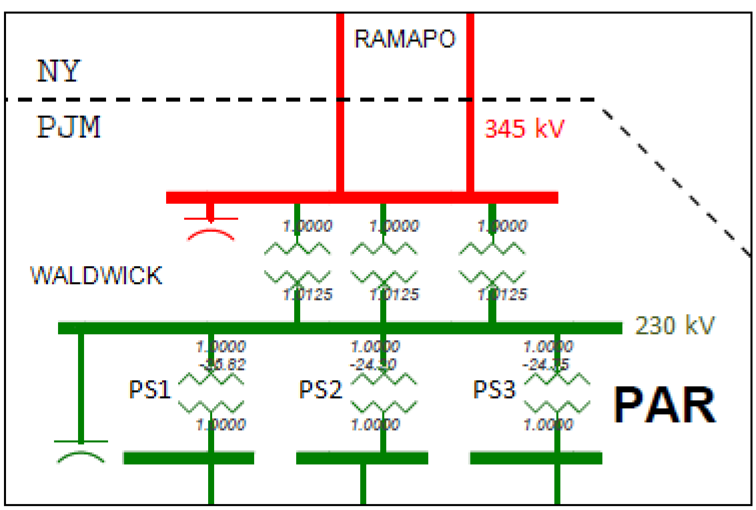


Figure 7. Waldwick PS1, PS2, & PS3

Farragut PS1 and PS2 are located at the Farragut station in NYISO on the 345kV path between Farragut (NYISO) and Hudson (PJM).

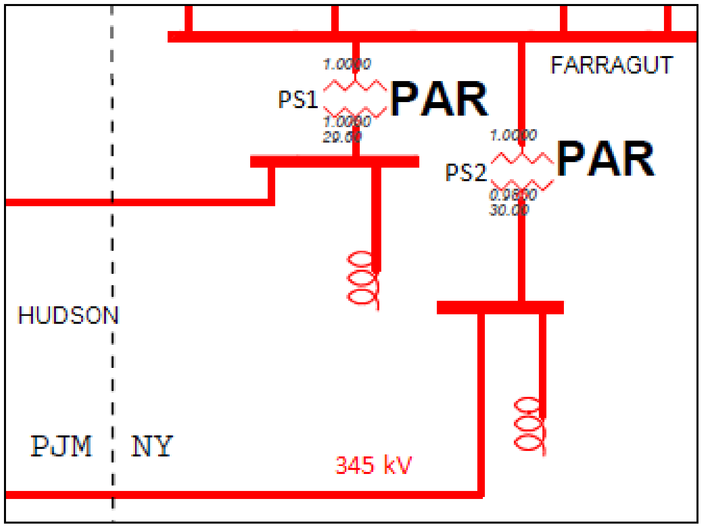


Figure 8. Farragut PS1 & PS2

Goethals PS1 is located on the 230kV path connecting Goethals (NYISO) and the Linden station (PJM).

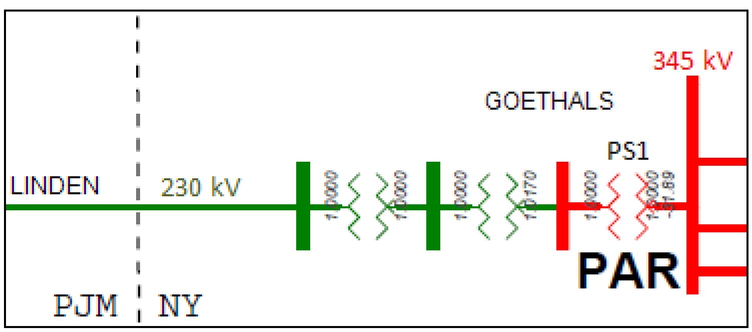


Figure 9. Goethals PS1

St. Lawrence PARs

Two PARs are located on the Ontario-New York (Adirondack) Interface. The PS33 is located on the 345kV circuit L33P at the St. Lawrence (IESO) station along with PSR34 on circuit L34P, also a 345kV circuit. These PARs are physically located within Ontario.

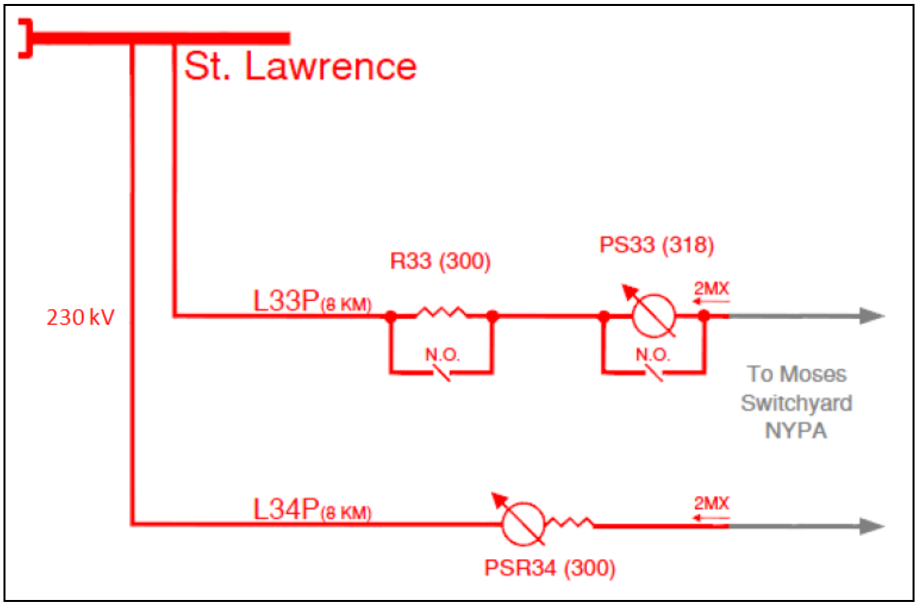


Figure 10. St. Lawrence PS33 & PSR34

Devices Excluded from Study

Several devices were determined to not be necessary to include within the study. These devices include the Linden Variable Frequency Transformer (VFT), Neptune DC line, and the PAR at Plattsburg station.

The Linden VFT (located in Linden, New Jersey) does not affect loop flow around Lake Erie and was not included within this study. There is an IDC CO to model the operation of this variable frequency transformer. This CO describes the operation of the Linden VFT.

The Neptune DC line is a DC line sourced in Eastern PJM that feeds into NYISO and can be dismissed as it does not create loop flow around Lake Erie.

The PAR at Plattsburg is located in northern New York on the 115 kV system with ties into the Vermont 115 kV system. The flows typically found on this path are between 70 and 120 MW range and is primarily operated for local security reasons to manage 115 kV limits.

Summary of PAR Operations

Below is a summary of PAR operations that can impact LEC. The study group gathered information on each PAR to understand each device's operations.

IESO-MISO PARs

Lambton PS4 & PS51 (L4D/L51D)

Although available for service, both the PS4 and PS51 PARs at Lambton currently operate in by-pass mode (out-of-service). The Lambton PARs can operate on neutral-tap (no phase-shift capability), however this would reduce the thermal capability of the interface by approx 700 MW (phase shifters have lower ratings). Per operating agreements, if in-service, system operators may move phase-shifters off neutral tap prior to implementing a 5% voltage reduction or shedding of firm load.

In conjunction with the other PARs on the Ontario-Michigan (IESO-MISO) interface, anticipated future operation is to control actual flow equal to scheduled flow. Manually setting the PARs on an hourly basis will attempt to achieve this outcome.

Keith PSR5 (J5D)

Keith PSR5 is currently the only in-service PAR on the Ontario-Michigan Interface. PSR5 is regularly used to maximize the thermal capability of the interface and reduce negative impacts of loop flow on post-thermal limitations on the interface. Prior to making any adjustments to the Keith PAR settings to manage local congestion, a conference call is established between MISO, IESO, MECS, and ITC.

Similar to the Lambton PARs, anticipated future operation is to control actual flow equal to scheduled flow. Manually setting the PARs on an hourly basis will attempt to achieve this outcome.

Bunce Creek PST1 & PST2 (B3N)[1]

Bunce Creek PST1 & PST2 are currently out of service waiting for approval to connect and operate. The intended in-service date for the Bunce Creek PST1 & PST2 has yet to be determined. The availability of PST1 & PST2 is pending further discussion between interconnected parties.

Anticipated future operation for the Bunce Creek PARs is to control actual flow equal to scheduled flow. Manually setting the PARs on an hourly basis will attempt to achieve this outcome in conjunction with the other PARs on the Ontario-Michigan (IESO-MISO) interface.

The objective of the Lambton, Keith, and Bunce Creek PARs, once operational together, will be to regulate the actual flow to match the schedule across the Ontario-Michigan interface. This will occur on an hourly basis (or more frequently if system conditions jeopardize reliability). The PARs on the Ontario-Michigan interface have the ability to offset 600 MW of circulation flow when placed in service.

There is no automatic phase-shifting capability on any of these phase shifters. Manual intervention by the system operator will be required when necessary. All parties involved strive to meet objectives of the devices on a pro-active basis. For example, if large interchange schedule changes are anticipated to

[1] Bunce Creek PST1 & PST2 are U.S. international facilities. The operation of U.S. international facilities is under the regulatory jurisdiction of the U.S Department of Energy (DOE). As of the issuing of this report, required DOE regulatory approval is still pending.

create thermal restrictions, any tap changes required to alleviate these concerns would be done in advance of the schedule changes.

The devices are responsive to market conditions and can control actual flows to economic schedules. As such, the market (dispatch) solution can reflect their operation. The market solution can adjust the flows to achieve various objectives or outcomes, including economic schedules, or targeted flows.

As for methods for measuring the LEC impacts of these PARs in both real-time and on an after-the fact basis, the NPCC-RFC working group can estimate the impact using their seasonal study models. System operators can normally accomplish this by adjusting the PARs of interest and keeping all else constant. It is difficult to study and measure PAR impact on LEC due to the difficulty of isolating the effect of adjusting the PARs in a dynamic system such as in real-time. Currently, tools are not in place to measure the impacts to LEC of PARs that are not conforming schedule to actual flows, although tools could be developed.

In accordance with agreements, the PARs are expected to be used to adjust flows closer to dispatch (normal mode), or directed to be off-schedule (i.e. offset), for assisting in managing reliability in other parts of the system. The PARs on the interface can offset up to 600 MW of circulation flow.

The following agreements govern the operation of IESO-MISO PARs:

- MISO-IESO-CO2[2]
- IESO Market Manual 7.4 – IESO Controlled Grid Operating Policies:
- http://www.ieso.ca/imoweb/pubs/systemOps/so_GridOpPolicies.pdf
- IESO Internal Manual 2.4-7 – Interchange Operations:
- Chapter 5 of the Market Rules for Ontario:
- http://www.ieso.ca/imoweb/pubs/marketRules/mr_chapter5.pdf

NYISO-PJM PARs

Waldwick PS1, PS2 & PS3; Farragut PS1 & PS2; Goethals PS1

The operation of the Waldwick/Farragut/Goethals phase shifters is in accordance with the transmission service agreements and the joint operating agreements incorporated into the NYISO tariffs. The PARs operate to deliver a contracted energy wheel from Ramapo in Rockland County to New York City via the 230 KV network in northern New Jersey, also known as the ABCJK wheel. The wheel typically transfers 1000 MW every hour of the day.

The operational objectives of the Waldwick/Farragut/Goethals are defined in the FERC approved operations protocol that expects actual power flows to conform with scheduled power flows within a 100 MW bandwidth. The objectives to maintain the wheel are met approximately 90% of all hours

[2] The MISO-IESO-CO2 is not yet finalized as of the issuing of this report.

based on historical observation and the performance obligations are reported monthly by PJM to NYISO, Consolidated Edison, and Public Service Electric & Gas. LEC control is not an operational objective applied to the Waldwick/Farragut/Goethals PARs.

PJM and NYISO discuss tap changes prior to adjusting the tap positions on the Waldwick/Farragut/Goethals. There is no automatic phase-shifting capability on any of these phase shifters. Manual intervention may be required and all parties involved strive to meet objectives of the device on a pro-active basis. For example, if large interchange schedule changes are anticipated to create thermal restrictions, any tap changes required to alleviate these concerns would be done in advance of the schedule changes.

The Waldwick/Farragut/Goethals phase shifters operate manually throughout the hour, as needed, to maintain actual flows within the target flows. Although tap movements were expected to be at or below 400 per month based on 20 operations (per PAR) in a 24-hour period, there have been no historical equipment limitations in operating these devices.

In the Day-Ahead Market, for the purposes of scheduling and pricing, the Security Constrained Unit Commitment (SCUC) desired flows will be established for the ABC, JK, and 5018 interconnections based on the following:

- Con Edison Company of New York's Day-Ahead Market hourly election for the "600/400MW Contracts"
- 13% of the Day-Ahead Market PJM-NYISO hourly interchange will be scheduled on the ABC interconnection
- -13% of the Day-Ahead Market PJM-NYISO hourly interchange will be scheduled on the JK interconnection
- 40% of the Day-Ahead Market PJM-NYISO hourly interchange will be scheduled on the Branchburg-Ramapo interconnection.

Flows in the Real-Time market will be established for the ABC, JK, and 5018 interconnections based on the current flow modified to reflect expected transaction schedule changes over the scheduling horizon. For the purposes of scheduling and pricing, the Real-Time Commitment/Real-Time Dispatch (RTC/RTD) desired flows will be established for ABC, JK, and 5018 interconnections based on the following:

- The current level of ABC, JK, and 5018 power flows (based on PAR MW telemetry values)
- 13% of the expected schedule changes to PJM-NYISO interchange within the next two and one-half hour scheduling horizon will be scheduled on the ABC interconnection
- -13% of the expected schedule changes to PJM-NYISO interchange within the next two and one-half hour scheduling horizon will be scheduled on the JK interconnection
- 40% of the expected schedule changes to PJM-NYISO interchange within the next two and one-half hour scheduling horizon will be scheduled on the Branchburg-Ramapo interconnection.

Tools are in place to quantify the degree to which the actual flows controlled by these devices conform to the contracted objectives. As for methods for measuring the LEC impacts of these PARs in both real-time and on an after-the fact basis, the NPCC-RFC working group can estimate the impact using their seasonal study models. System operators can normally accomplish this by adjusting the PARs of interest and keeping all else constant. It is difficult to study and measure PAR impact on LEC due to the difficulty of isolating the effect of adjusting the PARs in a dynamic system such as in real-time. Currently, tools do not exist to measure the impacts to LEC of PARs that are not conforming schedule to actual flows, although tools could be developed.

Generally, loop flows anywhere off the controlled path (e.g. other NYISO-PJM ties, PJM West-East transmission NYISO West-East transmission) are minimized when actual power flows are made to conform to scheduled power flows.

The PJM EMS does calculate the MW impact of PAR tap moves on transmission facilities, actual or post-contingency flows, as part of the PJM EMS Security Analysis package.

The operations of these PARs adhere to the following agreements:

- http://www.nyiso.com/public/webdocs/documents/tariffs/market_services/ms_attachments/att_m.pdf
- http://www.nyiso.com/public/webdocs/documents/tech_bulletins/tb_152.pdf

The operations of the PARS adhere to the following operating procedures:

http://www.pjm.com/~/media/documents/manuals/m03.ashx (Section 5: PSE&G/ConEd Wheel)

Ramapo PS1 & PS2

The Ramapo (5018) phase shifters are operated according to the Branchburg Ramapo 500 kV operating agreement referenced in the NYISO OATT attachment and the PJM/NYISO Unscheduled Transmission Services Agreement. The Ramapo PARs are primarily used to facilitate the delivery of PJM to NY transactions. In addition, the Ramapo PARs are adjusted when necessary to assist in the ABCJK wheel.

The 2009 average flows on Ramapo tie (5018) tie:

- Ramapo average off-peak = 661.46 MW from PJM to NYISO,
- Ramapo average on-peak = 647.59 MW from PJM to NYISO
- Average value of deviation from desired flow = 232.54 MW

The historical operation of theses phase shifters is expected to continue into the future.

The operational objective of the Ramapo phase shifters is to facilitate the delivery of PJM to NY scheduled transactions. Operating agreements expect the actual power flows conform to the desired power flow so long as such adjustments enhance reliable and efficient operations. As noted above, the average value of deviation from the desired flow is 232.54 MW. LEC control is not an operational objective applied to the Ramapo PARs.

The Ramapo phase shifters are operated manually throughout the hour, as needed, to maintain actual flows within the target flows. Although tap movements were expected to be at or below 400 per month based on 20 operations (per PAR) in a 24-hour period, there have been no historical equipment limitations in operating these devices. PJM and NYISO discuss tap changes prior to adjusting the tap positions on the Ramapo PARs. There is no automatic phase-shifting capability on any of these phase shifters. Manual intervention may be required and all parties involved strive to meet objectives of the device on a pro-active basis. For example, if large interchange schedule changes are anticipated to create thermal restrictions, any tap changes required to alleviate these concerns would be done in advance of the schedule changes. In the event where there may be conflicting objectives between the ABCJK and 5018 PAR operations, the 5018 PAR operations cannot adversely impact ABCJK since the ABCJK agreement is filed with FERC.

The Ramapo Phase shifters treatment in the Day-Ahead Market and in the Real-Time market is addressed above in the discussion of the Waldwick/Farragut/Goethals phase shifters.

Tools are in place to quantify the degree to which the actual flows controlled by these devices conform to the contracted objectives. As for methods for measuring the LEC impacts of these PARs in both real-time and on an after-the fact basis, the NPCC-RFC working group can estimate the impact using their seasonal study models. System operators can normally accomplish this by adjusting the PARs of interest and keeping all else constant. It is difficult to study and measure PAR impact on LEC due to the difficulty of isolating the effect of adjusting the PARs in a dynamic system such as in real-time. Currently, tools do not exist to measure the impacts to LEC of PARs that are not conforming schedule to actual flows, although tools could be developed.

The operations of these PARs adhere to the following agreements:

- http://www.nyiso.com/public/webdocs/documents/tariffs/market_services/ms_attachments/att_m.pdf
- http://www.nyiso.com/public/webdocs/documents/tech_bulletins/tb_152.pdf

St. Lawrence PAR

St. Lawrence PS33 & PSR34 (L33P/L34P)

The St. Lawrence PARs have historically been operated to alleviate post-thermals on both the Ontario-Michigan and Ontario-NY interfaces being the most active of all phase-shifters for these interfaces. LEC, Lake Ontario loop flow, along with schedule changes between IESO-HQTE and NYISO-HQTE, have a significant impact on the ONT-NY interface. As a result, phase-shifters frequently run out of tap settings. Approximately 10% of the flow change at St. Lawrence is reflected on the NY-Niagara Interface.

IESO and NYISO discuss tap changes prior to adjusting the tap positions on the St. Lawrence PARs. There is no automatic phase-shifting capability on any of these phase shifters. Manual intervention may be required and all parties involved strive to meet objectives of the device on a pro-active basis. For example, if large interchange schedule changes are anticipated to create thermal restrictions, any tap changes required to alleviate these concerns would be done in advance of the schedule changes.

The devices are responsive to market conditions and can control flows to economic schedules. As such, the market (dispatch) solution can reflect the PAR's operation. The market solution can adjust the flows to achieve various objectives/outcomes, including economic schedules, or targeted flows.

Ontario's dispatch algorithm (which produces the actual system dispatch instructions) does not consider tap position when scheduling. The calculations, however, factor in the targeted controlled flows, and these can be set to match the economic schedule. In "pre-dispatch" calculations, anticipated targeted flows are manually applied to each phase shifter based on:

- The average expected direction and magnitude of ONT-NY schedules for the next day/hour.
- Anticipated Loop Flow
- Anticipated impact of other schedules (i.e.: ONT-HQTE and NY-HQTE schedules)
- Each phase-shifter is usually set to share half of what is expected flow at the St. Lawrence interface.

In the IESO's real-time calculations, actual flows (acquired from telemetry) are manually applied to each phase-shifter in the dispatch model. The capability exists for the phase-shifters to have their targeted flows distributed automatically by the dispatch algorithm in both the pre-dispatch and real-time periods. Based on the total interchange schedule between ONT and NY, the target flow would be distributed on a pro-rata basis depending on thermal ratings. There is much greater accuracy in real-time calculations. The need for manual intervention and forecast inaccuracies in the pre-dispatch calculations can create dispatch anomalies in real-time. Consequently, these anomalies can lead to under or over scheduling situations on the interface.

Tools are in place to quantify the degree to which the actual flows controlled by these devices conform to the contracted objectives. As for methods for measuring the LEC impacts of these PARs in both real-time and on an after-the fact basis, the NPCC-RFC working group can estimate the impact using their seasonal study models. System operators can normally accomplish this by adjusting the PARs of interest and keeping all else constant. It is difficult to study and measure PAR impact on LEC due to the difficulty of isolating the effect of adjusting the PARs in a dynamic system such as in real-time. Currently, tools do not exist to measure the impacts to LEC of PARs that are not conforming schedule to actual flows, although tools could be developed.

In accordance with agreements, the PARs are expected to be used to adjust flows closer to dispatch (normal mode), or directed to be off-schedule (i.e. offset), for assisting in managing reliability in other parts of the system. Specifically, the New York – Ontario operating agreement states:

- The phase shifters may be moved by mutual consent to permit increased interconnection transactions between Ontario and New York and to make the most efficient use of New York-Ontario interface capacity, providing all relevant Operating Security Limits are observed.
- In the absence of a mutual agreement, the party whose internal transmission is loaded by the flow on L33P and L34P may direct the setting of the phase angle regulators to be placed at any tap which results in reduced loading of L33P and L34P to as little as zero MW flow.

The following agreements govern the PAR operations:

- NYISO-IMO-C01-R2: Principles of Operation for the NY-Ont Interconnection & Associated Facilities
- NYISO-IESO-C02-R4: Security Criteria Applicable to NY-Ont Interconnection
- IESO Market Manual 7.4 – IESO Controlled Grid Operating Policies:
- http://www.ieso.ca/imoweb/pubs/systemOps/so_GridOpPolicies.pdf
- IESO Internal Manual 2.4-7 – Interchange Operations
- Chapter 5 of the Market Rules for Ontario:
- http://www.ieso.ca/imoweb/pubs/marketRules/mr_chapter5.pdf

1999 MEN Study

The study group reviewed the November 1999 Michigan-Ontario Phase Angle Regulator Study – An Interregional Perspective conducted by the MAAC-ECAR-NPCC (MEN) Study Committee. The study group agreed a reproduction of the MEN analysis was not needed for the purpose of its study. Appendix D contains a copy of the November 1999 Michigan-Ontario Phase Angle Regulator.

Data Analysis

This study group evaluated data between the regions for the IESO-MISO, IESO-NYISO, and PJM-NYISO to identify the correlations between the flows on each of the interfaces. Once real-time data with the IESO-MISO PARs in service is obtained, this study group will review the in-service data to identify correlations between the LEC and flows on PAR devices, and compare the interactions of the PAR tap settings with each of the interfaces. As a point of caution, a strong observed correlation between variables (LEC versus PAR operation) does not necessarily imply that a causal relationship exists between those variables.[3] For example, a strong correlation does not necessarily imply that LEC causes PAR delta or PAR flow or a PAR delta or PAR flow does not necessarily cause LEC. Designed experiments (continued empirical analysis evaluating PAR tap settings) are the only way to determine causal relationships among data sets. **Appendix F – Correlation Analysis using Excel** contains supplemental reference information regarding correlation analysis with empirical models. The study group used references from **Appendix F** to establish the following criteria for correlation levels:

0.3 and below – weak correlation to LEC

0.4-0.5 – some correlation to LEC

0.6 – significant correlation to LEC

0.7 and above – strong correlation to LEC

Data Comparison

Data gathered during this study was based on market and real-time data from 2009. LEC (scheduled – actual flow) was calculated and compared among the three interfaces where PARs reside to determine data consistency. For the purposes of these scatter plots, the LEC flows in a positive direction are considered clock-wise around Lake Erie. Hourly averages were used to calculate LEC for the IESO-MISO, PJM-NYISO, and the IESO-NYISO interfaces.

MISO and IESO Data Comparison

To benchmark the data being used to calculate LEC between the companies, a correlation was performed on LEC flow calculations delivered by MISO and IESO for the IESO-MISO and the IESO-NYISO interface. The data used for these calculations was hourly averaged data collected during the calendar year 2009.

[3] Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers (New York: John Wiley & Sons, Inc, 1999) 446.

A correlation of 0.9988 was found for the LEC calculated using MISO and IESO data for the IESO-MISO interface. This data is presented in **Figure 11**.

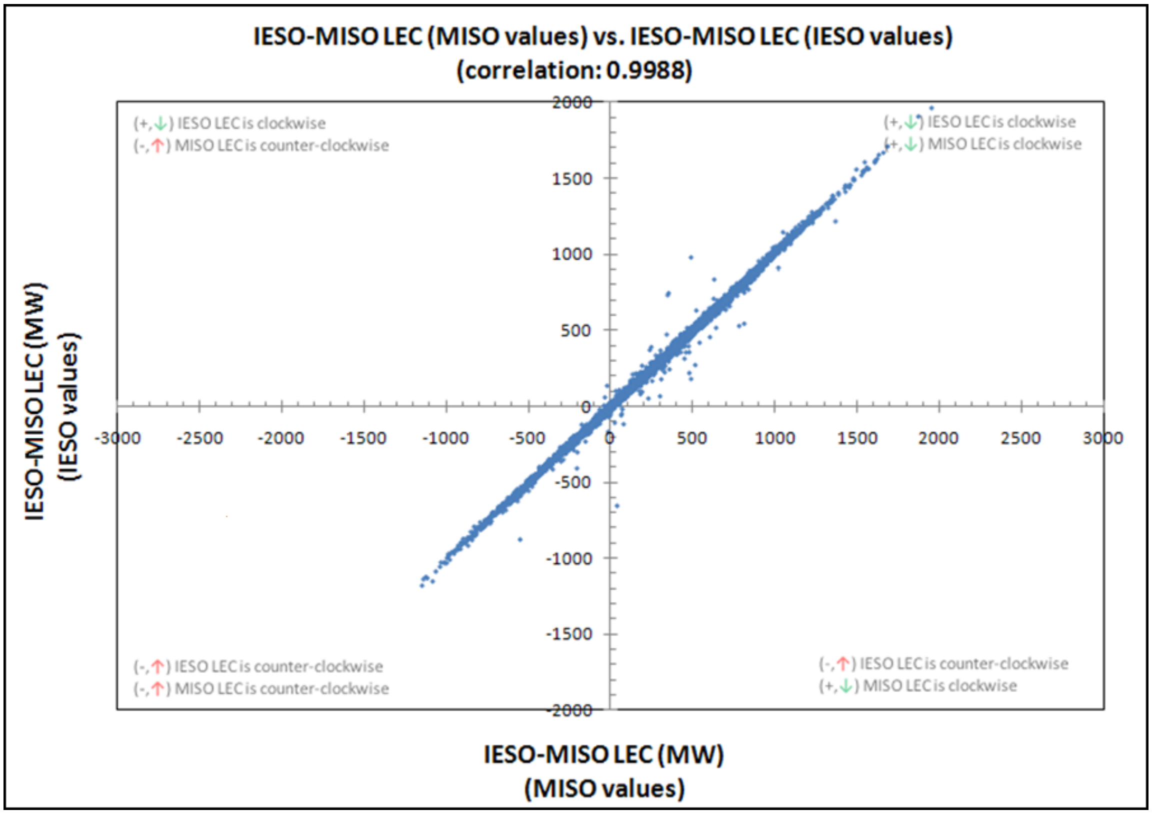


Figure 11. IESO-MISO LEC (MISO values) vs. IESO-MISO LEC (IESO values)

Conclusions: The group concluded from **Figure 11** that LEC derived from hourly averaged measurements on the IESO-MISO interface from sources in MISO or IESO will yield consistent values.

A correlation of 0.9974 was found for the LEC calculated using MISO and IESO hourly averaged data for the IESO-NYISO interface and is presented in **Figure 12**.

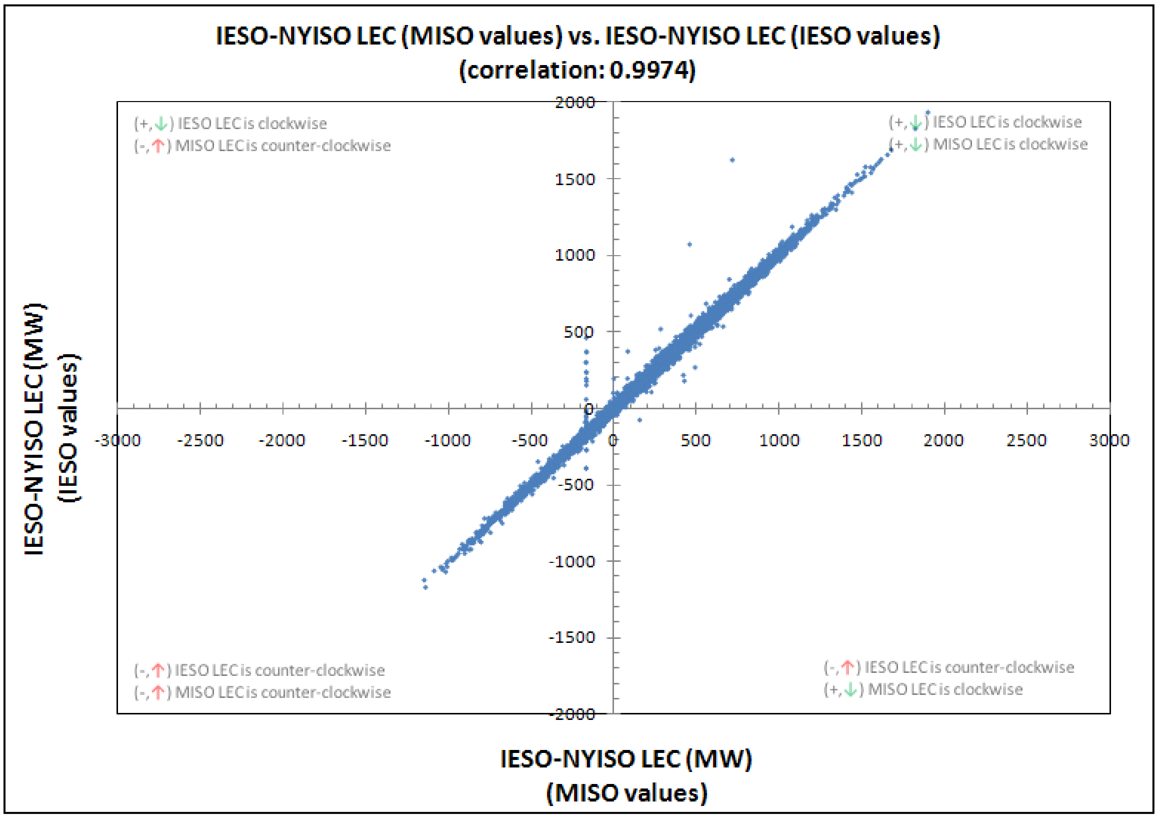


Figure 12. IESO-NYISO LEC (MISO values) vs. IESO-NYISO LEC (IESO values)

Conclusions: The group concluded from **Figure 12** that LEC derived from hourly averaged measurements on the IESO-NYISO interface from sources in MISO or IESO will yield consistent values.

LEC Flow Comparison between Interfaces

To benchmark LEC calculations between the interfaces a correlation of 0.9923 was found for the LEC calculated for the IESO-MISO and the IESO-NYISO interfaces when using MISO data for 2009. **Figure 13** below demonstrates this correlation calculation between the LEC flow calculated on the IESO-MISO interface and the IESO-NYISO interfaces.

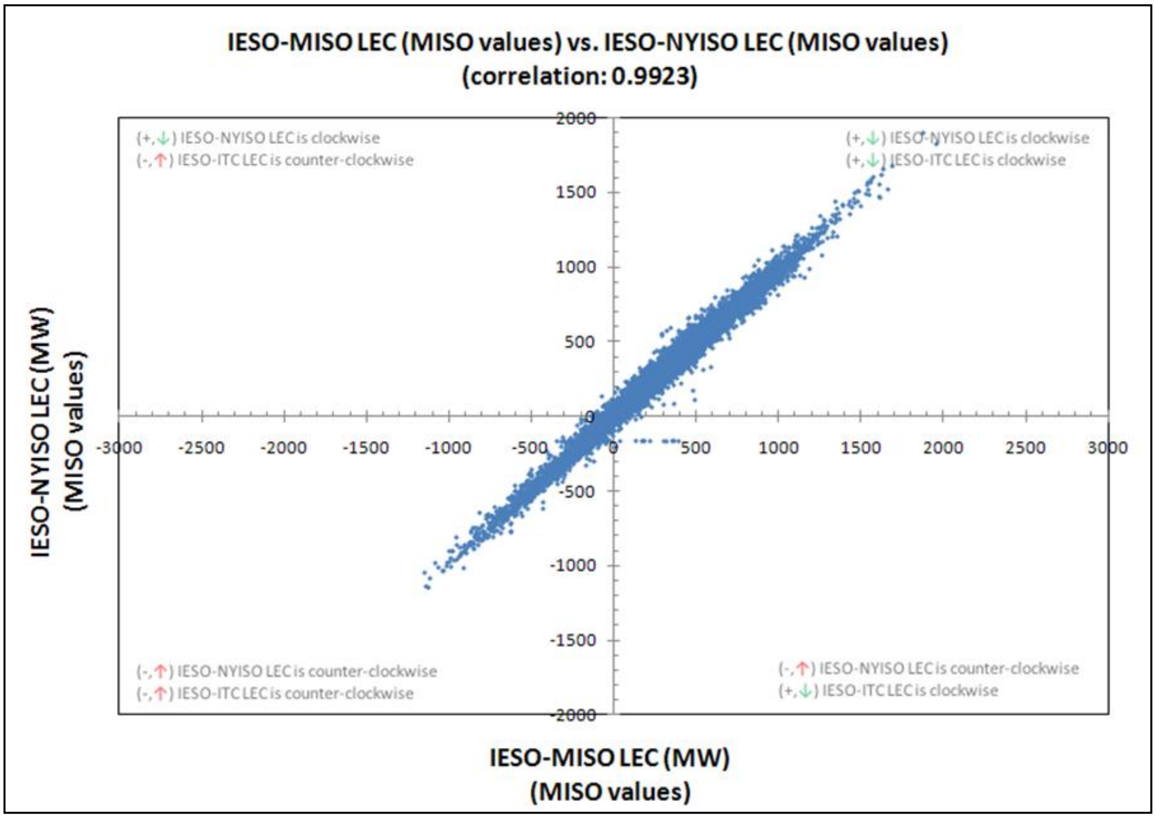


Figure 13. IESO-MISO LEC vs. IESO-NYISO LEC

Conclusions: The group concluded from Figure 13 that LEC measured across the IESO-MISO or IESO-NYISO interfaces will produce consistent results when using hourly averaged data.

Figure 14 compares LEC using hourly average data (PJM values) on the PJM-NYISO interface and hourly average data (MISO values) on the IESO-MISO interface for 2009. **Figure 14** displays a correlation of 0.9835 for the LEC calculated for the IESO-MISO (MISO values) and the PJM-NYISO (PJM values) interfaces.

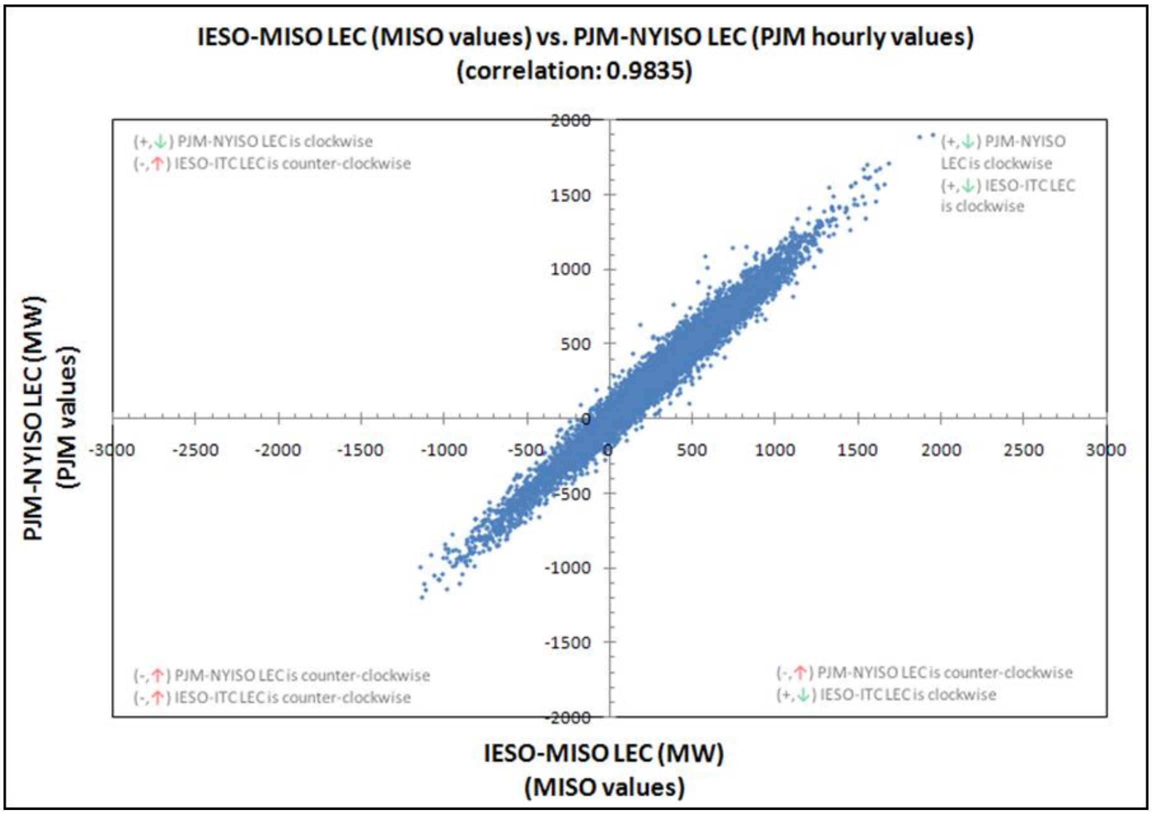


Figure 14. IESO-MISO LEC vs. PJM-NYISO LEC

Conclusions: The group concluded from Figure 14 that LEC measured across the IESO-MISO or PJM-NYISO interfaces will produce consistent results when using hourly averaged data.

Branchburg-Ramapo (5018) LEC Correlations

Upcoming analysis in Figures 15-18 display Branchburg – Ramapo (5018) Delta correlations with LEC using instantaneous values. The group analyzed LEC data between instantaneous values (0.9581) and hourly average data (0.9835) on the PJM-NYISO interface and found these two values strongly correlated. The group determined that hourly average data and instantaneous data are very well correlated.

For the purposes of the data displayed in these plots a positive (+) LEC denotes a clockwise direction of flow resulting in a north to south direction for the 5018 line. Likewise, a negative (-) LEC denotes a counterclockwise direction of flow resulting in a south to north direction for the 5018 line. Table 1 presents the conventions used for these plots.

Table 1. Sign and Symbol Conventions

Flow Indicator	Relative Sign	Denotes
↓	+	clockwise LEC / 5018 flow North to South (NYISO to PJM)
↑	-	Counter-clockwise LEC / 5018 flow South to North (PJM to NYISO)

Analysis was performed for the Branchburg-Ramapo (5018) line with an overall calculated correlation factor of 0.6392 with LEC using instantaneous data provided by PJM. The Ramapo Delta (Branchburg-Ramapo target flow subtracted from the actual flow) was compared with the LEC data taken at a corresponding time (15 min after the top of the hour). **Figure 15** displays the Ramapo Delta compared to the LEC measured from the PJM-NYISO interface using instantaneous values.

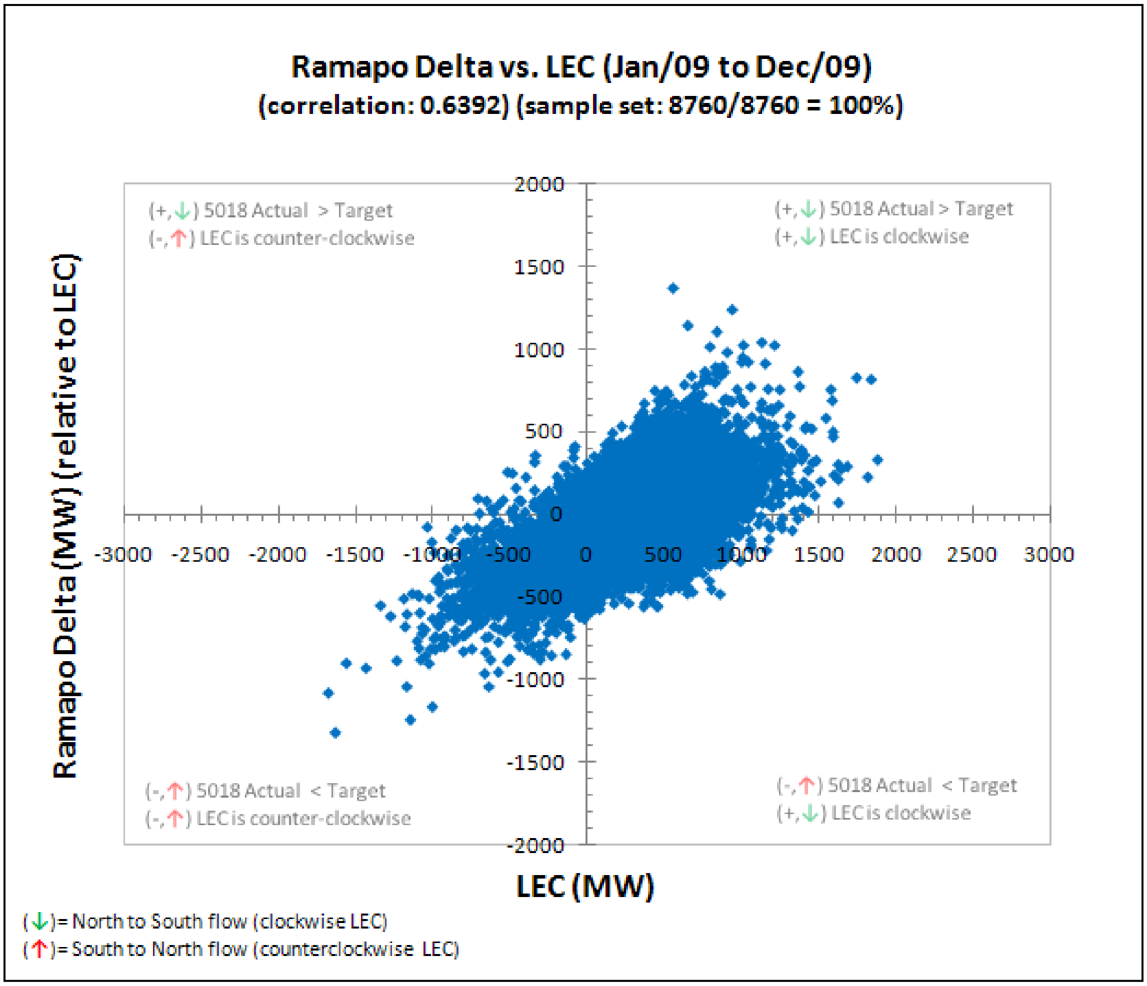


Figure 15. Ramapo vs. LEC – (Jan/09 to Dec/09)

Scenarios

The study group considered several different scenarios while determining where significant correlations might exist to LEC for the data gathered. In addition, the study group also considered three specific parameters when developing the scenarios. The first parameter was the direction of scheduled interface flows between PJM and NYISO. The second parameter was the direction of the target flow for the Branchburg-Ramapo (5018) line. The third parameter was the direction of the Delta (Target-Actual) flow for the Branchburg-Ramapo (5018) line. **Table 2** summarizes all scenarios that the study group analyzed for the 5018 line.

Table 2. Scenarios and Parameter Summary

Scenarios	Direction of Schedules for PJM-NYISO Interface	Target Flow: Branchburg-Ramapo (5018)	Delta Flow: Branchburg-Ramapo (5018)	Correlation:	Data set size (8760 total)	(%)
1	NYISO-PJM ↓	NYISO-PJM ↓	NYISO-PJM ↓	0.3808	160	1.8%
2	NYISO-PJM ↓	NYISO-PJM ↓	PJM-NYISO ↑	0.5773	507	5.8%
3	NYISO-PJM ↓	PJM - NYISO ↑	PJM-NYISO ↑	0.4316	28	0.3%
4	NYISO-PJM ↓	PJM - NYISO ↑	NYISO-PJM ↓	0.5257	30	0.3%
3 & 4	NYISO-PJM ↓	PJM - NYISO ↑		0.7188	58	0.7%
5	PJM - NYISO ↑	PJM - NYISO ↑	PJM - NYISO ↑	0.5129	2768	31.6%
6	PJM - NYISO ↑	PJM - NYISO ↑	NYISO-PJM ↓	0.3497	3624	41.4%
7	PJM - NYISO ↑	NYISO-PJM ↓	NYISO-PJM ↓	0.2707	731	8.3%
8	PJM - NYISO ↑	NYISO-PJM ↓	PJM - NYISO ↑	0.5000	912	10.4%
7 & 8	PJM - NYISO ↑	NYISO-PJM ↓		0.6196	1643	18.8%
				Points captured in plots	8760	100.0%

Scenario 3&4 comprises 0.7% of the 2009 hours and has a strong positive correlation of 0.7188. Scenario 7&8 comprises 18.8% of the 2009 hours and has a significant positive correlation to LEC. These two scenarios are included in the body of the report as they were either a significant correlation or a strong correlation. Scenarios 2, 3, 4, 5, and 8 show some positive correlation whereas Scenarios 1, 6, and 7 show a weak correlation to LEC. Scenarios 1, 2, 3, 4, 5, 6, 7, 8 are included in **Appendix E** for reference. Although various scenarios show some positive correlation and will contribute to LEC, only scenarios with strong or significant correlation were included in the body of the report.

Figure 16 combines the points captured in Scenario 3 and Scenario 4 resulting in Scenario 3 & 4. Listed below are the criteria for Scenario 3 & 4, which defines Figure 16:

- Interface Schedules for PJM-NYISO: Schedule is flowing from NYISO to PJM (↓)
- Target flow on the Branchburg-Ramapo line: Target flow is from PJM to NYISO (↑)

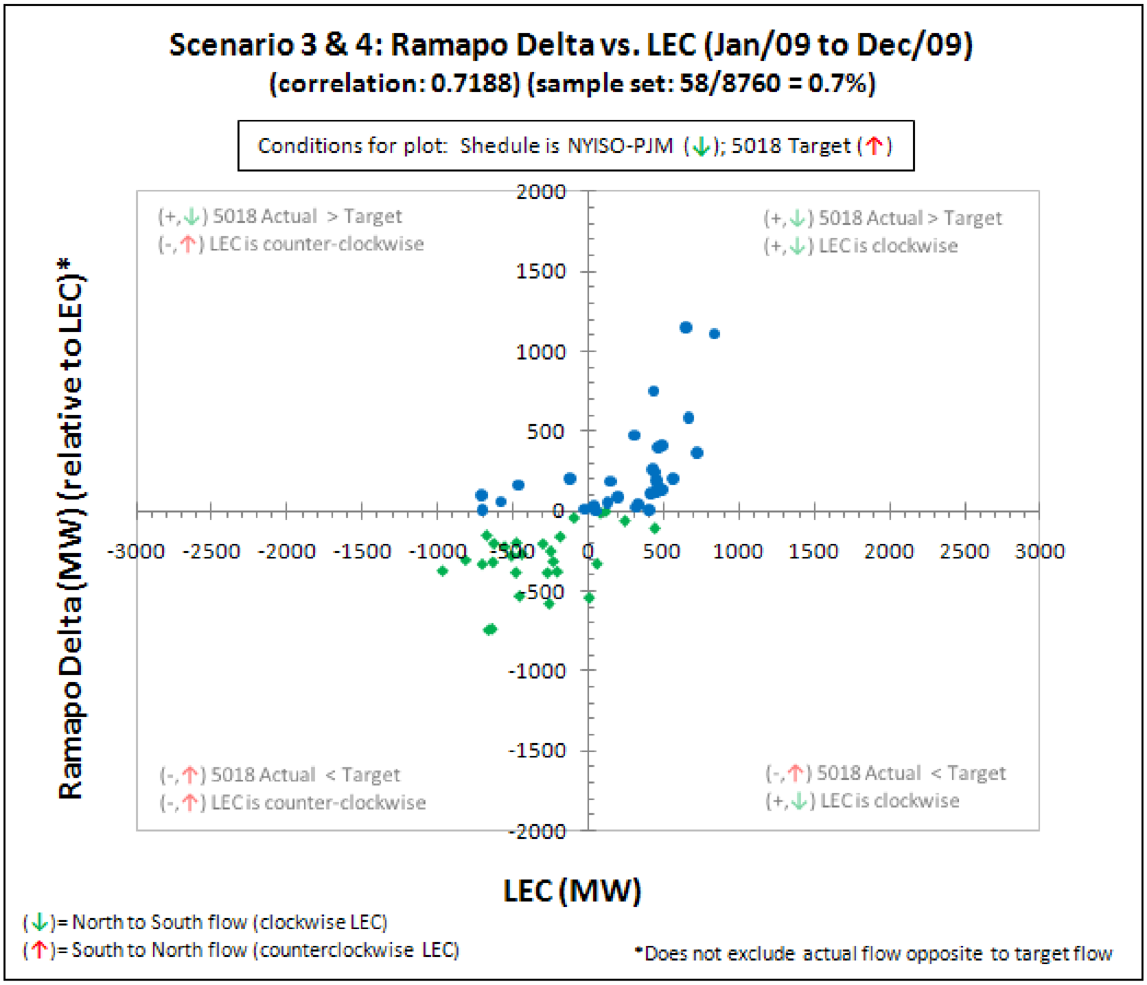


Figure 16. Scenario 3 & 4: Ramapo Delta vs. LEC (Jan/09 to Dec/09)

Conclusions: Scenario 3 & 4 has a correlation of 0.7188 which indicates that approximately 71.88 % of the variability in LEC is described by the linear relationship to the Ramapo delta when the schedule is flowing from NYISO to PJM and the target is in the opposite direction (PJM to NYISO). This occurred for a total of 0.7% of hours in 2009. This scenario shows that when the interface schedule (from NYISO to PJM) is flowing in the opposite direction of the Ramapo target (PJM to NYISO), operators can expect to see increased LEC. As discussed earlier, a strong observed correlation between variables does not necessarily imply that a causal relationship exists between those variables.

Figure 17 combines the points captured in Scenario 7 and Scenario 8 resulting in Scenario 7 & 8. Listed below are the criteria for Scenario 7 & 8, which defines **Figure 17**:

- Interface Schedules for PJM-NYISO: Schedule is flowing from PJM to NYISO (↑)
- Target flow on the Branchburg-Ramapo line: Target flow is from NYISO to PJM (↓)

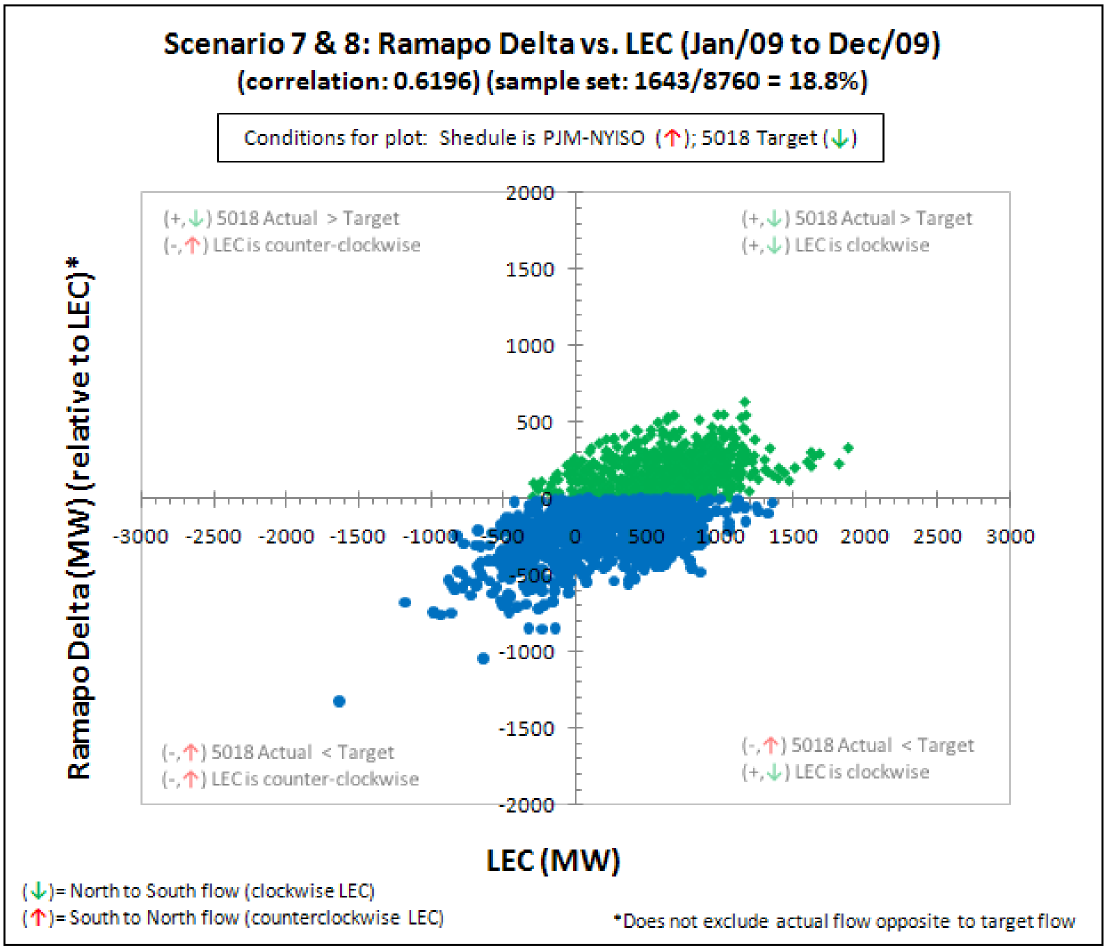


Figure 17. Scenario 7 & 8: Ramapo Delta vs. LEC (Jan/09 to Dec/09)

Conclusions: Scenario 7 & 8 has a correlation of 0.6196 which indicates that approximately 61.96% of the variability in LEC is described by the linear relationship to the Ramapo delta when the schedule is flowing from PJM to NYISO and the target is in the opposite direction (NYISO to PJM). This occurred for a total of 18.8 % of the hours in 2009. This scenario shows that when the interface schedule (from PJM to NYISO) is flowing in the opposite direction of the Ramapo target (NYISO to PJM), operators can expect to see increased LEC. As discussed earlier, a strong observed correlation between variables does not necessarily imply that a causal relationship exists between those variables.

St. Lawrence PAR LEC Correlations

The study group evaluated the correlation between LEC and the St. Lawrence PAR in Scenario 9 and found a weak positive correlation of 0.3812. There is no defined target flow on an hourly basis for the St. Lawrence PARs, hence only actual flow across the St. Lawrence PAR is analyzed with LEC. All hours of actual flow across the PAR in 2009 were analyzed against LEC. As the St. Lawrence PAR has a weak positive correlation to LEC it is included **Appendix E - Scenarios for Data Analysis** instead of in the body of the report.

J5D PAR LEC Correlations

The study group evaluated the correlation between LEC and the J5D PAR in Scenario 10 and found a weak negative correlation of 0.1802. There is no defined target flow on an hourly basis for the J5D PARs, hence only actual flow across the PAR is analyzed with LEC. All hours of actual flow across the PAR in 2009 were analyzed against LEC. As the J5D PAR has a weak positive correlation to LEC it is included **Appendix E - Scenarios for Data Analysis** instead of in the body of the report.

Scheduled Interface Flow LEC Correlations

The study group evaluated the correlations of PJM-NYISO, IESO-MISO, IESO-NYISO and PJM-MISO Scheduled Interchange versus LEC. The from-to identifier in this list was selected based on the predominant direction of schedules during 2009. However, the sign convention used for both Scheduled Interchange and LEC in the correlation analysis was always clockwise flow around Lake Erie is positive (as can been seen on the plots in Appendix E – Scenarios for Data Analysis). Scheduled Interchange and LEC was from hourly average data. LEC was always measured on the IESO-MISO interface. The correlation findings and an explanation for these findings follows:

- The PJM-NYISO Scheduled Interchange versus LEC in Scenario 11 shows a weak negative correlation of -.2925. In order to have a high correlation, instances when PJM-NYISO schedules are large must coincide with instances when LEC is large. The low correlation indicates the historic Scheduled Interchange on the PJM-NYISO interface did not coincide with other factors to contribute a strong or significant explanatory variable for LEC. A negative correlation exists because the predominant Scheduled Interchange is negative whereas LEC is positive (based on the convention that clockwise flow around Lake Erie is positive). A visual review of the Scenario 11 plot in Appendix E shows larger schedules from PJM to NYISO tend to coincide with higher clockwise LEC. All PJM-NYISO interchange manifests as a combination of LEC and PJM-NYISO direct tie flow.

- The IESO-MISO Scheduled Interchange versus LEC in Scenario 12 shows some negative correlation of -.5245. This is the highest correlation of the four interfaces. The high correlation indicates the historic Scheduled Interchange on the IESO-MISO interface coincided with other factors to contribute some explanatory variable for LEC. A negative correlation exists because the predominant Scheduled Interchange is negative whereas LEC is positive (based on the convention that clockwise flow around Lake Erie is positive). A visual review of the Scenario 12 plot in Appendix E shows larger schedules from IESO to MISO tend to coincide with higher clockwise LEC. All IESO-MISO interchange manifests as a combination of LEC and IESO-MISO direct tie flow.

- The IESO-NYISO Scheduled Interchange versus LEC in Scenario 13 showed a weak negative correlation of -.3160. The low correlation indicates the historic Scheduled Interchange on the IESO-NYISO interface did not coincide with other factors to contribute as a strong or significant explanatory variable for LEC. A negative correlation exists because the predominant Scheduled Interchange is positive but an inverse relationship exists where higher positive Scheduled Interchange causes lower LEC. A visual review of the Scenario 13 plot shows larger schedules from IESO to NYISO tend to occur with lower LEC. All IESO-NYISO interchange manifests as a combination of LEC and direct IESO-NYISO tie flow.

- The PJM-MISO Scheduled Interchange versus LEC in Scenario 14 showed a weak negative correlation of -.3394. The low correlation indicates the historic Scheduled Interchange on the IESO-NYISO interface did not coincide with other factors to contribute as a strong or significant explanatory variable for LEC. A negative correlation exists because the predominant Scheduled Interchange is positive but an inverse relationship exists where higher positive Scheduled Interchange causes lower LEC. A visual review of the Scenario 14 plot shows larger schedules from PJM to MISO tend to occur with low LEC. The majority PJM-MISO interchange manifests as a combination of LEC and direct PJM-MISO tie flow. For PJM-MISO an alternate circulation path, other than LEC, exists through SPP and SERC.

While none of these four scenarios show significant or strong correlation by themselves, these Scheduled Interchanges do not occur in isolation from each other. By summing all of the average hourly interchanges on the four interfaces while taking into account the sign convention of Scheduled Interchange, a correlation analysis found a significant negative correlation of -.6562. This plot is included as **Figure 18** since it met the minimum threshold to include in the main body of the report.

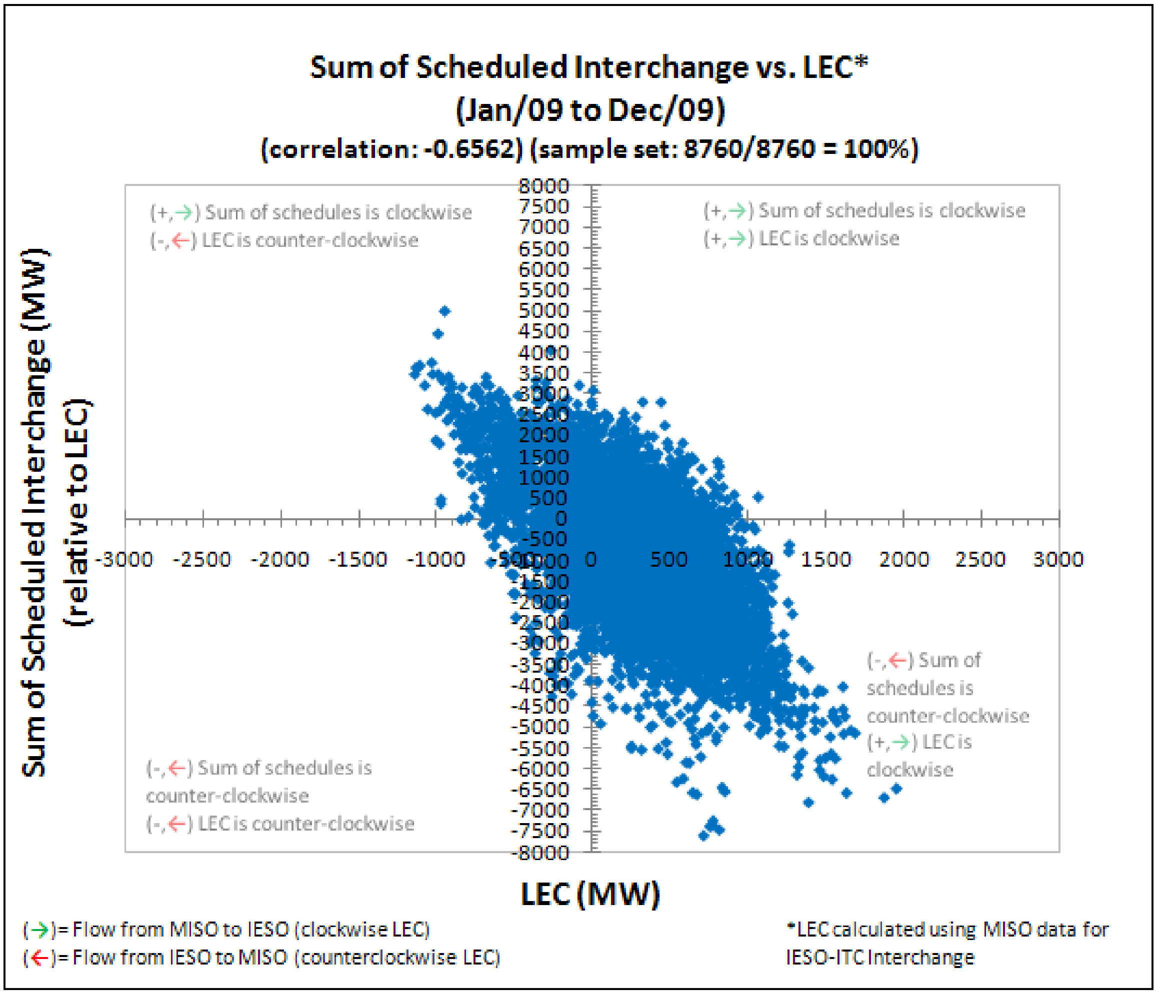


Figure 18. Sum of Scheduled Interchange vs. LEC (Jan/09 to Dec/09)

Conclusions: The study group concluded that there are two explanations for this high correlation. First, there are instances where Scheduled Interchange on an interface is not that great but summing all interfaces produces high Scheduled Interchange that coincides with high LEC. Second, LEC is measuring the combined impact of all Scheduled Interchange on all interfaces, not just one at a time. Because of the reasons given for the negative correlations in the four scenarios, it makes sense that the combined correlation is negative and greater than the correlation of each scenario.

Future Work

Two options exist regarding future work investigating LEC. First, the study group considered reproducing the 1999 MEN Study. Second, another option considered was to study the interaction of the PARs on the LEC flows using empirical data once the Ontario-Michigan PARs are in service.

Reproduction of MEN Study

The study group reviewed the results produced by the original 1999 MEN Study and deemed it unnecessary to reproduce the MEN Study in 2011. The consensus was reproducing the MEN Study would not provide any additional insight beyond what the original MEN Study had already provided.

Empirical Model

The option for future work chosen by this study group is to collect and analyze empirical data once the Ontario – Michigan PARs are placed in service. As a strong observed correlation between variables does not necessarily imply that a causal relationship exists between those variables, continued analysis must occur. The study group will analyze the tap settings and corresponding flows on the PARs at Ramapo, Ontario-Michigan, and St. Lawrence with the LEC. PAR tap settings must be evaluated with LEC and PAR flows to determine causal relationships among data sets.

The study group will perform a regression analysis between PAR operations among the regions and the effects those operations have on the LEC using an empirical model with scatter diagrams. Once operational data is obtained after the Ontario – Michigan PARs are in service, the study group will be able to begin regression and correlation evaluations (including causal relationships) on PAR tap settings, flows on PAR devices, coordinated PAR operations, and LEC.

Appendix A – RPCDC Study Template – IESO-MISO

Regional Power Control Device Coordinated Study

Template

10/18/2010

The purpose of this template is to obtain information necessary for successfully completing the Regional Power Control Device Coordinated Study being jointly performed by IESO, MISO, NYISO, and PJM.

Purpose:

The objective of this template is to gather information from the participating regions to identify the set of PARs, variable frequency transformers, series capacitors and other such devices that have the ability to alter flows around Lake Erie and should be included in the coordination process.

Please respond to each question/request as it pertains to each region.

Subject Matter Experts

Identify your company's subject matter expert(s) responsible for this study. Please include the person's title, organization and their role as it pertains to this study. Include additional sheets if necessary.

Response:

SME Name	Title	Organization	Role
Peter Sergejewich	Director – Corporate Planning	IESO	Co-ordinate IESO input
Tom Mallinger	Consulting Advisor Real Time Operations	Midwest ISO	
Christina Drake	Manager Central Regional Operations Engineering	Midwest ISO	
Nathan Kirk	Central Region Operations Engineer	Midwest ISO	

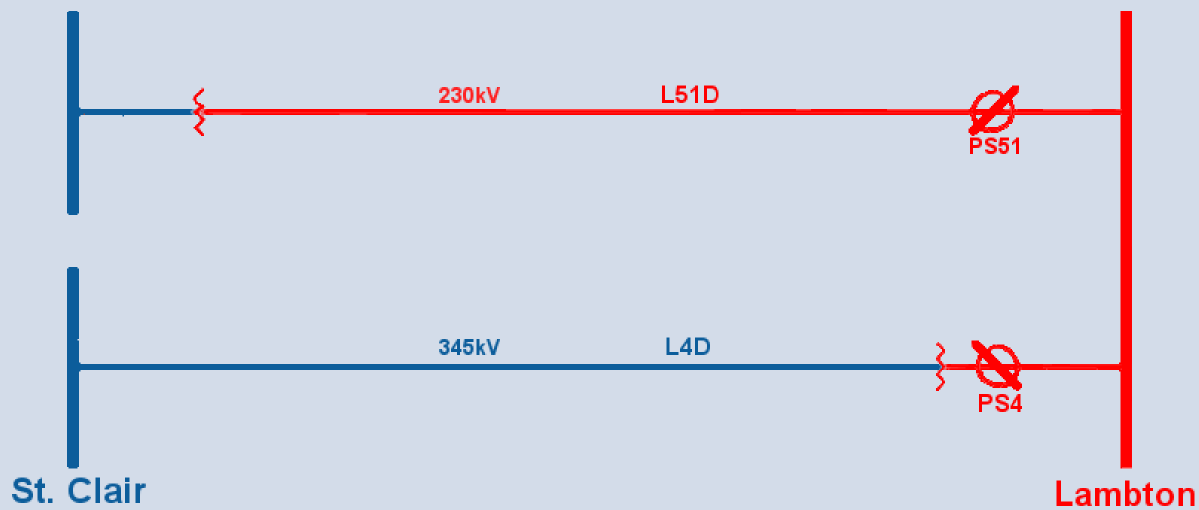
Section 1.

Identify the PARs that have the ability to alter flows around Lake Erie and should be included in the coordination process.

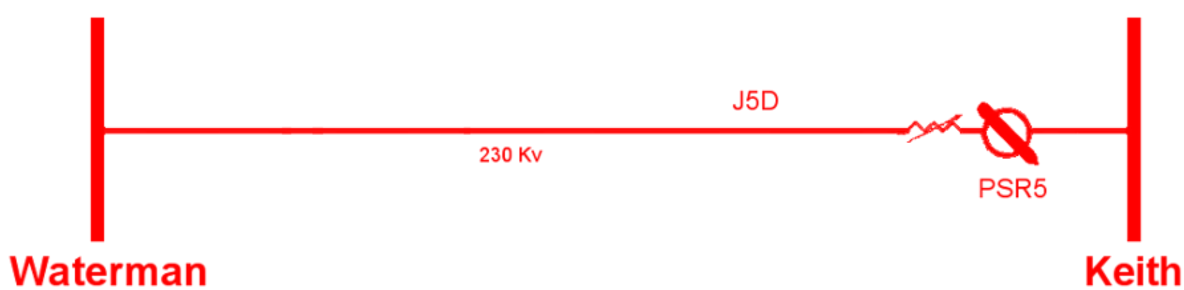
Response:

The following PARs are located on the Ontario/Michigan interface.

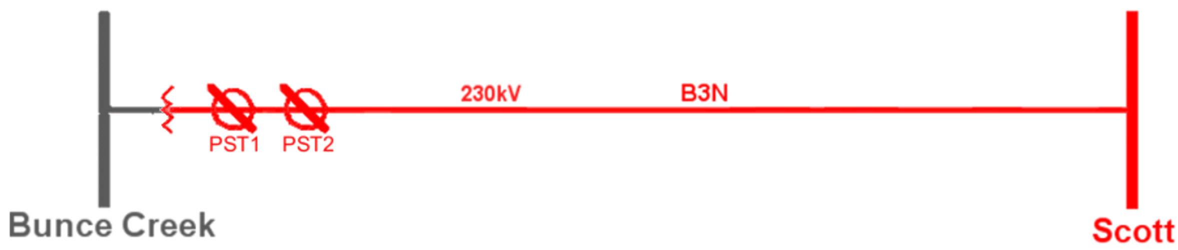
Lambton PS51 (on circuit L51D: St. Clair (MISO) – Lambton (IESO) 230kV)
Lambton PS4 (on circuit L4D: St. Clair (MISO) – Lambton (IESO) 345kV)



Keith PSR5 (on circuit J5D: Waterman (MISO) – Keith (IESO) 230kV)



Bunce Creek PST1 & PST2 (on circuit B3N: Bunce Creek (MISO) – Scott (IESO) 230kV)



Section 2.

Identify the operating characteristics of each device:

A. Review the historical operation of these devices and identify their expected future operation:
   1. Describe how they are operated on a daily, hourly and monthly basis and variations in the operation that are time or system conditions dependent.

Response:

Lambton PS4 & PS51 (L4D/L51D)

- Although available for service, both are operated in by-pass mode (out-of-service)
- Can be operated on neutral-tap (no phase-shift capability), however this would reduce the thermal capability of the interface by approx 700 MW (phase shifters have lower ratings)
- As per operating agreements, if in-service, phase-shifters may be moved off neutral tap prior to implementing a 5% voltage reduction or shedding of firm load
- Testing may also be performed to prove control and ensure readiness of equipment
- Anticipated future operation would be to assist in making flow = schedule
- Anticipated future operation includes setting manually on an hourly basis

Keith PSR5 (J5D)

- Currently the only in-service PAR on the Michigan Interface
- Regularly used to maximize the thermal capability of the interface and reduce negative impacts of loop flow on post-thermal limitations on the interface
- A conference call is established between IESO, MISO, MECS, and ITC prior to making any adjustments
- Anticipated future operation would be to assist in making flow = schedule
- Anticipated future operation includes setting manually on an hourly basis

Bunce Creek PST1 & PST2 (B3N)

- Currently O/S with no ability or approval to connect/operate
- Intended in-service date prior to end of 2011
- Availability is pending further discussion between interconnected parties
- Anticipated future operation would be to assist in making flow = schedule
- Anticipated future operation includes setting manually on an hourly basis

2. Describe the objectives that are trying to be met and how successful the devices are at meeting these objectives.

Response:

The objective of these devices, once operational, will be to regulate the flow to match the schedule across the Ontario-Michigan interface. This would be undertaken on (down to) an hourly basis or more frequently if reliability is jeopardized. The PARs on the MI-ONT interface have the ability to offset 600MW of circulation flow when placed in service.

B. Describe the physical characteristics associated with the operation of each device:
  1. Does the device operate in an automatic mode to meet the objectives or does it rely on manual intervention on a one-time or continuous basis?

Response:

There is no automatic phase-shifting capability on any of these phase shifters. Manual intervention is needed, however only as required. All parties involved strive to meet objectives met by this equipment on a pro-active basis. For example, if large interchange schedules are anticipated to create thermal restrictions, any tap changes required to alleviate these concerns would be done so in advance of the schedule changes.

2. What are the equipment restrictions and the system restrictions that affect device operations?

Response:

Equipment restrictions consist of:

- thermal ratings of the devices
- angle capability (total range and discrete tap positions)
- duty cycle (frequency and total changes) on the tap changers

Thermal ratings and angle capabilities are provided below. Duty cycles are not available.

MVA Ratings of Michigan-Ontario Tie Line Phase shifters

Tie	**kV (1)**	**Summer (2)**			**Winter (2)**		
		Continu-ous	**LTE**	**STE** (3)	**Continu-ous**	**LTE**	**STE** (3)
PS4	242	845	845	1170	845	845	1170
PS51	242	845	845	1170	845	845	1170
PSR5	230	574	574	1170	673	673	969
PST1 & PST2*	---	---	---	---	---	---	---

(1) MVA ratings are based on an operating voltage of 230kV for the 220 kV system
(2) In real time, the ratings for Ontario facilities are derived on the basis of actual weather information.
(3) 15 minutes STE are based on 80% pre-load

Michigan-Ontario Tie Circuit Energization, and Voltage & Angle Taps

Circuit	**Energize from**	**Voltage Taps**	**Angle Taps**
L4D	Michigan	T7 35 taps T8 35 taps down MX out	PS4 2*33 taps down MW in
L51D	Michigan	T351 35 taps down MX out	PS51 2*33 taps down MW in
J5D	Michigan	PSR5 33 taps down MX in	PSR5 35 taps down MW out
B3N*	Michigan	Not Available	---

*PST1 and PST2 are not operational

3. Is there a change in state from where the device is regulating to meet the objective function to where the device is not longer able to regulate (i.e. a PAR being operated at one end of a tap range)?

Response:

When unscheduled flows on the MI-ONT interface exceed the PARS ability to limit circulation flows the state of the interface will transition to a non-regulating status in the IDC. The PARs on the MI-ONT interface have the ability to offset 600MW of circulation flow when placed in service.

C. Does an operating guide, procedure or contractual arrangement exist that defines the operation of the device? Is there any flexibility in the use of this device or other devices to meet the objective function?

Response:

An operating agreement is still in development for this PAR.

Other Ontario documents:

IESO Market Manual 7.4 – IESO Controlled Grid Operating Policies:

http://www.ieso.ca/imoweb/pubs/systemOps/so_GridOpPolicies.pdf

IESO Internal Manual 2.4-7 – Interchange Operations:
Chapter 5 of the Market Rules for Ontario:

http://www.ieso.ca/imoweb/pubs/marketRules/mr_chapter5.pdf

D. Market impact on operations:
   1. Are these devices responsive to market conditions? Is their operation reflected in the market solution? Will the market solution try to adjust the device to optimize the market solution or are the devices responsive to price signals sent by the market?

Response:

The devices are responsive to market conditions. They can be used to control flows to economic schedules. As such, their operation can be reflected in the market (dispatch) solution.
The market solution can adjust the flows to achieve various objectives/outcomes, including economic schedules, or targeted flows.

The devices are not directly responsive to price signals.
For additional details see response to #2 below.

   2. How are operation of these devices modeled in the day-ahead market and the real-time market? Are there market challenges associated with the operation of these devices (i.e. interface pricing)?

Response:

Ontario's dispatch algorithm (which produces the actual system dispatch instructions) does not take tap position into consideration when scheduling. The calculations, however, factor in the targeted controlled flows, and these can be set to match the economic schedule.

In our "pre-dispatch" calculations, anticipated targeted flows are manually applied to each phase shifter based on:

- The average expected direction and magnitude of ONT-MICH schedules for the next day/hour.
- Anticipated Loop Flow
- Anticipated impact of other schedules (ie: ONT-NY and ONT-HQ schedules)

In the IESO's real-time calculations, actual flows (acquired from telemetry) are manually applied to each phase-shifter in the dispatch model.

An operating agreement is still in development for this PAR.

Section 3.

Identify how operations of the devices impact Lake Erie loop flow:

A. Identify flowgates around Lake Erie that are impacted by each device:

Response:

NERC ID	Geographic Location
2012	Indiana - Michigan Tie
7009	Ontario - New York Tie
7106	New York - Ontario Tie
9010	Ohio - Michigan Tie
9021	Michigan - Indiana Tie
9084	West Michigan - Ontario Tie
9156	New York - Ontario Tie
9159	Ontario - West Michigan Tie
9160	Ontario - New York Tie
3814	Upper Peninsula - Lower Peninsula Michigan Tie
2382	Indiana - Michigan Tie
2184	North West Ohio - South East Michigan Tie
2185	North West Ohio - South East Michigan Tie
2236	North East Ohio - Michigan Tie
2241	North Ohio - South East Michigan Tie
2246	North Ohio - South East Michigan Tie
2859	North Ohio - South East Michigan Tie
2982	North Ohio - South East Michigan Tie
2951	North Indiana - South West Michigan Tie
2381	North Indiana - South West Michigan Tie
2216	North Indiana - South West Michigan Tie

2217	North Indiana - South West Michigan Tie
2218	North Indiana - South West Michigan Tie
2298	North Indiana - South West Michigan Tie
2340	North Indiana - South West Michigan Tie
2341	North Indiana - South West Michigan Tie
2470	North East Ohio - North West Pennsylvania Tie
2478	North East Ohio - West Pennsylvania Tie
2513	South East Michigan - North Ohio Tie
2861	South East Michigan - North Ohio Tie
3570	South East Wisconsin - North East Illinois Tie
3571	South East Wisconsin - North East Illinois Tie
3586	South East Wisconsin - North East Illinois Tie
3587	South East Wisconsin - North East Illinois Tie
3593	South East Wisconsin - North East Illinois Tie
3771	South East Wisconsin - North East Illinois Tie
561	South East Wisconsin - North East Illinois Tie
530	South East Wisconsin - North East Illinois Tie
531	South East Wisconsin - North East Illinois Tie
532	South East Wisconsin - North East Illinois Tie
7101	Ontario
7102	Ontario
7104	Ontario
9161	Ontario - Minnesota Tie
9162	Ontario - Manitoba Tie
7108	West Ontario
7109	West Ontario
6134	Manitoba - Ontario Tie
6142	Manitoba - Ontario Tie
6153	Minnesota - Ontario Tie
6154	Minnesota - Ontario Tie

1. Is there a way to measure these impacts in both real-time and on an after-the-fact basis? Are there existing tools that can be used to measure the impact of each device or are new tools needed?

Response:

Tools are in place to quantify the degree to which the actual flows controlled by these devices conform to the contracted objectives. As for methods for measuring the Lake Erie Circulation impacts of these PARs in both real-time and on an after-the fact basis, the NPCC-RFC working group can estimate the impact using their seasonal study models. System operators can normally accomplish this by adjusting the PARs of interest and keeping all else constant. It is difficult to study and measure PAR impact on Lake Erie Circulation due to the difficulty of isolating the effect of adjusting the PARs in a dynamic system such as in real-time. Currently, tools do not exist to measure the impacts to Lake Erie circulation of PARs that are not conforming schedule to actual flows, although tools could be developed.

2. Under what circumstances would this device add to or reduce loop flow?

Response:

In accordance with agreements, the PARs are expected to be used to adjust flows closer to dispatch (normal mode), or directed to be off-schedule (i.e. offset), for assisting in managing reliability in other parts of the system. This is expected to be applied to the Michigan PARs, and is the case for all the other PARs involving Ontario. The PARs on the interface will offset up to 600MW of circulation flow.

Appendix A:

Please attach associated documents such as operating guides or procedures that may have been described in earlier responses.

Attachment 1: IDC Modifications Due to MI-ONT PARs Operations_071910.doc

Attachment 2: Market Flow-Allocation Modifications Due to MI-ONT Pars Operations_071910.doc

IDC Modifications Due to MI-ONT PARs Operations

Overview

The MI-ONT PARs are expected to be available for regulated operation later this year. This regulated operation will involve setting the taps at the beginning of the hour based on hour-ahead forecasts of next-hour schedules and next-hour circulation flow. As long as tap range is available, the goal will be to have next-hour actual flow equal next-hour scheduled flow. However, because actual next-hour conditions can be different than projected conditions, and because conditions will change during the hour, it is realized that there will continue to be some level of circulation flow in real-time. There are no plans to make intra-hour tap adjustments to address this circulation flow. We will need to have some operational experience before we can determine whether this is an issue of not.

Modifications to the IDC

The modifications to the IDC to model the MI-ONT PARs were made in 2009. A change was requested this spring to reflect the addition of the fourth PAR on the B3N segment. According to the Phase Shifters and DC Ties in the IDC document, the PARs will be operated in one of three modes:

1. Regulate mode, the IDC models tags that can impact the phase shifter interface in two different ways, depending on how the tags are created by the customer.
    - A tag not using the phase shifter POR/POD will see the regulating phase shifter as an open circuit and will distribute 100% of the flow across the rest of the network model.
    - A tag using the phase shifters POR/POD will be seen by IDC as flowing over the DECO-ONT flowgate. The percentage of flow that will be directly modeled over the phase shifters is based on the selected Distribution Factor.
2. Non-regulate mode, all transactions are subject to all TLR curtailments. In this case, even if the transaction is identified as flowing over the phase shifter POR/POD path, it is subject to all TLR curtailments (the Distribution Factor entered in the Phase Shifter Detail screen do not apply). The TDF will accurately represent the current tap position.
3. By-pass mode, the model uses the impedance at the neutral tap setting for the transformer.
    - While the phase shifter is set to by-pass mode in the IDC, an SDX branch outage of the phase shifter will not take effect.
    - If a user wants an SDX branch outage of the transformer to be reflected in the IDC, the phase shifter should be left in non-regulate mode.

The following describes how each of the three modes will be used to model the MI-ONT PARs in the IDC:

- When in regulate mode, a Distribution Factor will be used to indicate how schedules across the MI-ONT interface split between the four segments that form the interface. This split will be determined by reviewing the flow on each segment when the PARs are regulating to determine on a proportional basis, the amount of interface loading on each segment. It is expected that these will represent typical values and will not be updated over time. Even though the MI-ONT PARs will be manually set once an hour and will not be automatically adjusting the taps during the hour, it will be considered in regulate mode except during periods when it is at max tap/min tap (non-regulate mode) of the hourly regulation has been disabled (by-pass mode).

- When in non-regulate mode, this is the equivalent of a max tap/min tap position. We have two suggested changes to the IDC involving the non-regulate mode.
    1. The tap settings on each of the four segments will be set to optimize the effectiveness of the PARs while minimizing the circulation flows between the four segments. This will likely result in a condition where one of the four PARs will hit a max tap/min tap position while the other three segments still have tap range available. When this occurs, the IDC will reflect a change on all four PARs from regulate mode to non-regulate mode (or vice versa). Currently, the IDC requires that each of the four PARs have their status changed from regulate to non-regulate (or vice versa). The suggested change is to have a single flag in the IDC that resets all four PARs with a single status change.
    2. Currently, non-regulate mode assumes all of the transactions are subject to TLR (even if the transaction is identified as flowing over the phase shifter POR/POD path). This means the interface is considered free flowing for all transactions (not 100% flow for those scheduled across the interface and 0% for those not scheduled across the interface). The PARs have the ability to offset between 400-600 MW of circulation flow. This means circulation flow would need to reach 600 MW (assuming the high end of the range) before the PARs are at max tap/min tap and switching from regulated mode to non-regulated mode. Only those circulating flows that exceed 600 MW will appear as free flowing across the interface. When the scheduled flow across the interface is added to the circulation flow, the combined flow is significant before the PARs reach max tap/min tap. This is the reason for stating that when max tap/min tap is reached, we will assume the transactions across the interface continue to contribute 100% of their impacts to the interface. This only applies to those transactions scheduled across the interface. All other transactions and GTL flows will assume a free flowing system that have some portion across the interface and the remainder on the remaining system based on the impedance of PARs relative to the AC system (will need to take into account the tap position when determining PAR impact). This will require a change to the IDC.
- When in by-pass mode, it will appear as the PARs are on neutral tap and not regulating. There is a comment made in the Phase Shifters and DC Ties in the IDC document that a branch outage of the transformer cannot be reflected in the IDC unless the phase shifter is left in non-regulate mode. We don't understand why this is the case. We believe it should be the opposite such that a branch outage can only be taken in the by-pass case and cannot be taken in the non-regulate case. We will want further input from the IDCWG on why this statement is in the document.

A suggestion has been made that we rename the IDC status from non-regulate mode to max tap mode and by-pass mode to non-regulate mode. The name change was intended to remove confusion as to what each mode means. A problem with changing the names is that the statuses have already been in use for some time and just changing the names will add confusion. Another problem is that max tap is not the correct term. It should be max tap/min tap since the tap range in use will be dependent on the direction of the circulation flows.

Market Flow/Allocation Modifications Due to MI-ONT PARs

Overview

The MI-ONT PARs are expected to be available for regulated operation later this year. This regulated operation will involve setting the taps at the beginning of the hour based on hour-ahead forecasts of next-hour schedules and next-hour circulation flow. As long as tap range is available, the goal will be to have next-hour actual flow equal next-hour scheduled flow. However, because actual next-hour conditions can be different than projected conditions, and because conditions will change during the hour, it is realized that there will continue to be some level of circulation flow in real-time. There are no plans to make intra-hour tap adjustments to address this circulation flow. We will need to have some operational experience before we can determine whether this is an issue of not.

Modifications to the Market Flow/Allocation Calculations

When the PARs are regulating and have not run out of tap range (not at max tap or min tap), transactions scheduled across the interface will assume 100% impact across the interface and all other transactions will assume 0% impact across the interface (an open interface). Market flows will be treated like all other transactions in that they will have 0% impact across the interface when the PARs are regulating.

When the PARs are non-regulating because they have run-out of tap range (at either max tap or min tap), we will continue to assume transactions scheduled across the interface have 100% impact across the interface. All other schedules and market flows will assume the interface is a free-flowing system where a portion will go across the interface and the remainder will go through the remaining system based on the impedance of the PARs relative to the AC system (will need to take into account the tap position when determining PAR impedance).

When the PARs are by-passed, this is the equivalent of being on neutral tap. Both the transactions scheduled across the interface as well as all other schedules and market flows will assume the interface is a free-flowing system (the way it is operated today).

The challenge is to calculate real-time and next hour market flows and to assign allocations even though the PARs can be operating in one of three modes. The market flow calculation is relatively straight forward so we will cover it first. The market flows will consider the interface as either open (PARs in regulating mode) or free flowing (PARs in non-regulating or by-pass mode). The IDC will have the status of the PARs that can be used in real-time. We may need to move this status into the SDX if the market flow calculator cannot get it from the IDC. We will assume that whatever the status is in real-time, it will continue with that status for next-hour every time the next-hour calculation is made. Whether the PARs are non-regulating or by-passed only affects the impedance used for the PARs when calculation market flows in a free-flowing system.

Because the allocations are determined on a seasonal, monthly, weekly, two day-ahead and day-ahead basis, we will need to make some kind of assumption on the mode of the PAR operation that will be used in the allocations calculation. We will use the following assumptions in the allocations calculation:

- Unless the SDX indicates the PARs are out-of-service, we will assume the PARs are in-service and in regulating mode when making the allocations calculation on all flowgates. This effectively means the historic reservations across the interface will assume 100% impacts across the interface and all other historic reservations will assume 0% impact across the interface. All historic GTL impacts will be computed as if it is an open interface. If should be noted that for IESO flowgates, MISO does not make allocations to determine market flow limits. MISO uses its GTL impacts down to 0% from the day-ahead impact calculation to set its Priority 7 limit.
- The SDX will need to have some kind of indicator when it expects the PARs to either be out-of-service (open) or in-service but on neutral tap (by-pass). We will need to have a discussion with the Outage Coordination group on how this could be modeled in the SDX.
- Under these assumptions, we will never compute allocations as if the PARs are non-regulating (either at max tap or min tap). However, there will be times when they are non-regulating and real-time/next-hour market flows will be computed as if it were a free-flowing system. In general, this should be ok except for IESO and NYISO flowgates that experience Lake Erie circulation flow. All of the market flows on these flowgates will be placed into the non-firm bucket if we do not make any other calculation (keep in mind that these are external flowgates that use day-ahead GTL impacts down to 0% to set their Priority 7 limit).
- As stated previously, for all flowgates we will compute allocations assuming the interface is open (PARs regulating) unless the SDX indicates they are out-of-service. For the IESO and NYISO flowgates, this will produce zero GTL impacts down to 0%. We are recommending that a second GTL impacts calculation be performed where we assume it is a free-flowing interface (for this calculation we can assume the PARs are on neutral tap). We would then have two sets of GTL impacts for the IESO and NYISO flowgates. One with zero GTL impacts down to 0% based on an open interface and another with non-zero GTL impacts down to 0% based on a free-flowing interface. Based on the real-time status of the PARs, one of these two sets of GTL impacts would be used to set the priority of the market flows reported to the IDC. We would also need to compute the GTL impacts down to 5% for the second set of market flows reported to the IDC.

As long as IESO and NYISO do not participate in a flowgate allocation process, we will use the above assumptions to compute market flow limits on their flowgates when the PARs are regulating. The MISO allocation engine will need to make the dual GTL calculation for MISO market flows and the PJM allocation engine will need to make the dual GTL calculation for PJM market flows. Only the MISO allocation engine and the PJM allocation engine will need modifications for these calculations on IESO and NYISO flowgates. While SPP could also be impacted, they currently do not report their market flows to the IDC on IESO and NYISO flowgates.

For the other allocation engines (TVA, SPP and MAPP), they only need to recognize the status of the interface when calculating allocations (the impacts are based on the impacts received from OATI). There is no need to change these other allocation engines. It will be important that the OATI impact calculation is able to distinguish whether the PARs are available for service and regulating or they are out-of-service. As indicated in the second bullet above, this requires some kind of indicator in the SDX when it expects the PARs to either be out-of-service (open) on in-service but on neutral tap (by-pass).

MISO and PJM will also need to modify our current-hour and next-hour market flow calculator to reflect the status of the PARs (in regulate mode, in non-regulate mode or in by-pass mode). The status of the PARs is available in real-time form the IDC. To the extent the market flow calculators rely on distribution factors form the EMS model, it will be important to have the correct status of the PARs in the EMS model.

Modeling the MI-ONT PARs will require a modification to parallel flow visualization CO 283 that is making the GTL calculation for MISO, PJM and all other entities in the Eastern Interconnection.

Appendix B – RPCDC Study Template – NYISO-PJM

Regional Power Control Device Coordinated Study

Template

8/24/2010

The purpose of this template is to obtain information necessary for successfully completing the Regional Power Control Device Coordinated Study being jointly performed by IESO, MISO, NYISO, and PJM.

Purpose:

The objective of this template is to gather information from the participating regions to identify the set of PARs, variable frequency transformers, series capacitors and other such devices that have the ability to alter flows around Lake Erie and should be included in the coordination process.

Please respond to each question/request as it pertains to each region.

Subject Matter Experts

Identify your company's subject matter expert(s) responsible for this study. Please include the person's title, organization and their role as it pertains to this study. Include additional sheets if necessary.

Response:

SME Name	Title	Organization	Role
David Mahlmann	Mgr Operations Engineering	NYISO	
David Souder	Mgr Operations Planning	PJM	

Section 1.

Identify the PARs that have the ability to alter flows around Lake Erie and should be included in the coordination study

Response:

There are eight phase shifters that regulate the flow of power across the eastern AC ties between the NYISO and PJM systems:

Ramapo PS1 (Con Edison)
Ramapo PS2 (Con Edison)

Waldwick PS1 (Public Service Electric & Gas)
Waldwick PS2 (Public Service Electric & Gas)
Waldwick PS3 (Public Service Electric & Gas)
Farragut PS1 (Con Edison)
Farragut PS2 (Con Edison)
Goethals PS1 (Con Edison)

In addition to the line controlled by these phase shifters there are 2-345KV, 2-230 KV and 3-115KV free flowing ties in along the western portion of the NYISO/PJM interface.

The attached Figure 1 (Ramapo – ABCJK PARs) indicates the proximity of the Ramapo and ABC JK PARs.

Section 2.

Identify the operating characteristics of each device:

A. Review the historical operation of these devices and identify their expected future operation:
    1. Describe how they are operated on a daily, hourly and monthly basis and variations in the operation that are time or system conditions dependent.

Response:

The operation of the Waldwick/Farragut/Goethals phase shifters is in accordance with the transmission service agreements and the joint operating agreements which are incorporated into the NYISO tariff. The PARs are operated to deliver a contracted energy wheel from Ramapo in Rockland County to New York City via the 230 KV network in northern New Jersey. The wheel typically transfers 1000 MW every hour of the day.

The Ramapo (5018) phase shifters are operated according to the Branchburg Ramapo 500 kV operating agreement referenced in the NYISO OATT attachment and the PJM/NYISO Unscheduled Transmission Services Agreement.

The Ramapo PARs are primarily used to facilitate the delivery of PJM to NY transactions. In addition, the Ramapo PARs are adjusted when necessary to assist in the ABCJK wheel.

The 2009 average flows on Ramapo tie (5018) tie:
Ramapo average off-peak = 661.46 MW from PJM to NYISO,
Ramapo average on-peak = 647.59 MW from PJM to NYISO
Average value of deviation from desired flow = 232.54 MW

The historical operation of theses phase shifters is expected to continue into the future.

2. Describe the objectives that are trying to be met and how successful the devices are at meeting these objectives.

Response:

The operational objectives of the Waldwick/Farragut/Goethals are defined in the FERC approved operations protocol that expect that actual power flows conform with scheduled power flows within a 100MW bandwidth. The objectives to maintain the wheel are met approximately 90% of all hours based on historical observation and the performance obligations are reported monthly by PJM to NYISO, Consolidated Edison and Public Service Electric & Gas.

The operational objective of the Ramapo phase shifters is to facilitate the delivery of PJM to NY transactions. Operating agreements expect the actual power flows conform to the desired power flow so long as such adjustments enhance reliable and efficient operations. As noted above, the average value of deviation from the desired flow is 232.54 MW.

B. Describe the physical characteristics associated with the operation of each device:
1. Does the device operate in an automatic mode to meet the objectives or does it rely on manual intervention on a one-time or continuous basis?

Response:

All the PARS discussed here are operated throughout the hour manual intervention as needed to maintain actual flows within the target flows.

2. What are the equipment restrictions and the system restrictions that affect device operations?

Response:

Although tap movements were expected to be at or below 400 per month based on 20 operations (per PAR) in a 24-hour period, there have been no historical equipment limitations in operating these devices.

3. Is there a change in state from where the device is regulating to meet the objective function to where the device is not longer able to regulate (i.e. a PAR being operated at one end of a tap range)?

Response:

There is no change of state give that the PARs are expected to have the capability to meet their operating objectives.

C. Does an operating guide, procedure or contractual arrangement exist that defines the operation of the device? Is there any flexibility in the use of this device or other devices to meet the objective function?

Response:

The operation of the Waldwick/Farragut/Goethals phase shifters is in accordance with the transmission service agreements and the joint operating agreements approved by FERC and incorporated into the NYISO tariffs.

The operation of the Ramapo phase shifters is in accordance operating agreements referenced in the NYISO tariffs and the Unscheduled Transmission Services Agreement. The primary operational objective of the Ramapo phase shifters is to facilitate the delivery of PJM to NY transactions. The secondary operational objective is to assist in securing local transmission. There can be limited flexibility in defining lower priority operating objectives.

D. Market impact of expected PAR schedules:
   1. Are these devices responsive to market conditions? Is their operation reflected in the market solution? Will the market solution try to adjust the device to optimize the market solution or are the devices responsive to price signals sent by the market?

Response:

The operation of the devices in accordance with the FERC approved tariffs are reflected in the markets as explained in the response to the next question.

   2. How are operation of these devices modeled in the day-ahead market and the real-time market? Are there market challenges associated with the operation of these devices (i.e. interface pricing)?

Response:

In the Day-Ahead Market, for the purposes of scheduling and pricing, the Security Constrained Unit Commitment (SCUC) desired flows will be established for the ABC, JK, and 5018 interconnections based on the following:

- Con Edison Company of New York's Day-Ahead Market hourly election for the "600/400MW Contracts"
- 13% of the Day-Ahead Market PJM-NYISO hourly interchange will be scheduled on the ABC interconnection
- -13% of the Day-Ahead Market PJM-NYISO hourly interchange will be scheduled on the JK interconnection

- 40% of the Day-Ahead Market PJM-NYISO hourly interchange will be scheduled on the Branchburg-Ramapo interconnection.

Flows in the Real-Time market will be established for the ABC, JK, and 5018 interconnections based on the current flow modified to reflect expected transaction schedule changes over the scheduling horizon. For the purposes of scheduling and pricing, the Real-Time Commitment/Real-Time Dispatch (RTC/RTD) desired flows will be established for ABC, JK, and 5018 interconnections based on the following:

- The current level of ABC, JK, and 5018 power flows (based on PAR MW telemetry values)
- 13% of the expected schedule changes to PJM-NYISO interchange within the next two and one-half hour scheduling horizon will be scheduled on the ABC interconnection
- -13% of the expected schedule changes to PJM-NYISO interchange within the next two and one-half hour scheduling horizon will be scheduled on the JK interconnection
- 40% of the expected schedule changes to PJM-NYISO interchange within the next two and one-half hour scheduling horizon will be scheduled on the Branchburg-Ramapo interconnection.

Section 3.

Identify how operations of the devices impact Lake Erie loop flow:

A. Identify flowgates around Lake Erie that are impacted by each device:

Response:

To the extent that the devices conform scheduled to actual flows it is anticipated that there will be minimal impact on Lake Erie loop flows.
NYISO Submitted Flowgates:

BLIP	ADIRONDACK - ONT
NBLIP	FRONTIER - ONT
IMO-MECS	PJM-NYIS
MECS-IMO	NYIS-ONT
NY-IMO	ONT-NYIS
IMO-NY	Branchburg-Ramapo (5018) 500 kV line
Frontier-IMO	Hudson-Farragut (B-3402) 345 kV line
IMO-Frontier	Hudson-Farragut (C-3403) 345 kV line
IMO-Adirondack	Waldwick-South Mahwah (J-3410) 345 kV
Adirondack-IMO	Waldwick-South Mahwah (K-3411) 345 kV
QFW	Linden-Goethals (A-2253) 230 kV line
FETT	Warren-Falconer 115 kV line
DYSINGER	Erie East-South Ripley 230 kV line
WEST CENTRAL TIES	East Towanda-Hillside 230 kV line
MOSES - SOUTH TIES	East Sayre-North Waverly 115 kV line

CENTRAL EAST TIES	Tiffany-Goudey 115 kV line
TOTAL EAST TIES	Homer City-Stolle Road 345 kV line
UPNY - CONED TIES	Homer City-Watercure Road 345 kV line
ONT - FRONTIER	PJM Eastern Interface
ONT - ADIRONDACK	PJM Central Interface
	PJM Western Interface

To the extent that the devices conform scheduled to actual flows it is anticipated that there will be minimal impact on Lake Erie loop flows.
PJM Submitted Flowgates:

FG 3 – PJM Eastern Interface
FG 4 - PJM Central Interface
FG 5 - PJM Western Interface
FG 6: Branchburg-Ramapo 500 kV
FG 7: Hudson-Farragut (B-3402) 345 kV line
FG 8: Hudson-Farragut (C-3403) 345 kV line
FG 9: Waldwick-South Mahwah (J-3410) 345 kV
FG 10: Waldwick-South Mahwah (K-3411) 345 kV
FG 11: Linden-Goethals 230 kV
FG 23: Roseland-Cedar Grove F 230 kV l/o Roseland-Cedar Grove B 230 kV
FG 50: AP South Interface
FG 51: AEP-DOM l/o Baker-Broadford 765 kV
FG 60: Black Oak-Bedington 500 kV line l/o Keystone-Juniata 500 kV line
FG 100: Kammer #200 765/500 kV xfmr l/o Belmont-Harrison 500
FG 101: Kammer #200 765/500 kV xfmr l/o Kammer-South Canton 765 kV
FG 102: Kammer #200 765/500-kV xfmr l/o Belmont 765/500-kV xfmr
FG 112: Sammis-Wylie Ridge 345 kV line l/o Belmont-Harrison 500 kV
FG 514: Cordova-Nelson 345 kV (15503) l/o H471-Nelson 345 kV (15504)
FG 558: Cordova-Nelson 345 kV (15503 line)
FG 2131: Sammis-Wylie Ridge 345 kV
FG 2301: Bedington – Black Oak Interface
FG 2370: Bedington-Doubs 500 kV l/o Pruntytown-Mt. Storm 500 kV
FG 2380: Kammer .100 345/138kV xfmr l/o Tidd-WestBellair-Kammer 345kV
FG 2406: Cloverdale-Lexington 500 kV l/o Pruntytown-Mt. Storm 500 kV
FG 2516: Burnham-Munster 345 kV
FG 2975: Crete-St Johns Tap 345 kV l/o Dumont-Wilton Center 765 kV line
FG 3250: 155 Nelson-111 Electric Junction (15502) 345 kV l/o Cherry Valley- Silver Lake (15616) 345 kV
FG 3245: 15616 Cher-Silv for 15502 Nels-EJ
FG 3271: State Line-Wolf Lake 138 flo Wilton Center-Dumont 765

1. Is there a way to measure these impacts in both real-time and on an after-the-fact basis? Are there existing tools that can be used to measure the impact of each device or are new tools needed?

Response:

Tools are in place to quantify the degree to which the actual flows controlled by these devices conform to the contracted objectives. As for methods for measuring the Lake Erie Circulation impacts of these PARs in both real-time and on an after-the fact basis, the NPCC-RFC working group can estimate the impact using their seasonal study models. System operators can normally accomplish this by adjusting the PARs of interest and keeping all else constant. It is difficult to study and measure PAR impact on Lake Erie Circulation due to the difficulty of isolating the effect of adjusting the PARs in a dynamic system such as in real-time. Currently, tools do not exist to measure the impacts to Lake Erie circulation of PARs that are not conforming schedule to actual flows, although tools could be developed.

2. Under what circumstances would this device add to or reduce loop flow?

Response:

Loop flows are minimized when actual power flows are made to conform to scheduled power flows.

Appendix A:

Please attach associated documents such as operating guides or procedures that may have been described in earlier responses.110

http://www.nyiso.com/public/webdocs/documents/tariffs/market_services/ms_attachments/att_m.pdf

http://www.nyiso.com/public/webdocs/documents/tariffs/oatt/oatt_attachments/att_cc.pdf

http://www.nyiso.com/public/webdocs/documents/tech_bulletins/tb_152.pdf

Unscheduled Transmission Services Agreement – PJM Interconnection, L.L.C., Docket ERO1-1115-000 (1/30/2001

PJM Manual 3, Section 5 RAMAPO PAR OPERATING INSTRUCTION page 288
http://www.pjm.com/~/media/documents/manuals/m03.ashx

Appendix C – RPCDC Study Template – IESO-NYISO

Regional Power Control Device Coordinated Study

Template

8/24/2010

The purpose of this template is to obtain information necessary for successfully completing the Regional Power Control Device Coordinated Study being jointly performed by IESO, MISO, NYISO, and PJM.

Purpose:

The objective of this template is to gather information from the participating regions to identify the set of PARs, variable frequency transformers, series capacitors and other such devices that have the ability to alter flows around Lake Erie and should be included in the coordination study.

Please respond to each question/request as it pertains to each region.

Subject Matter Experts

Identify your company's subject matter expert(s) responsible for this study. Please include the person's title, organization and their role as it pertains to this study. Include additional sheets if necessary.

Response:

SME Name	Title	Organization	Role
Peter Sergejewich	Director – Corporate Planning	IESO	Co-ordinate IESO input

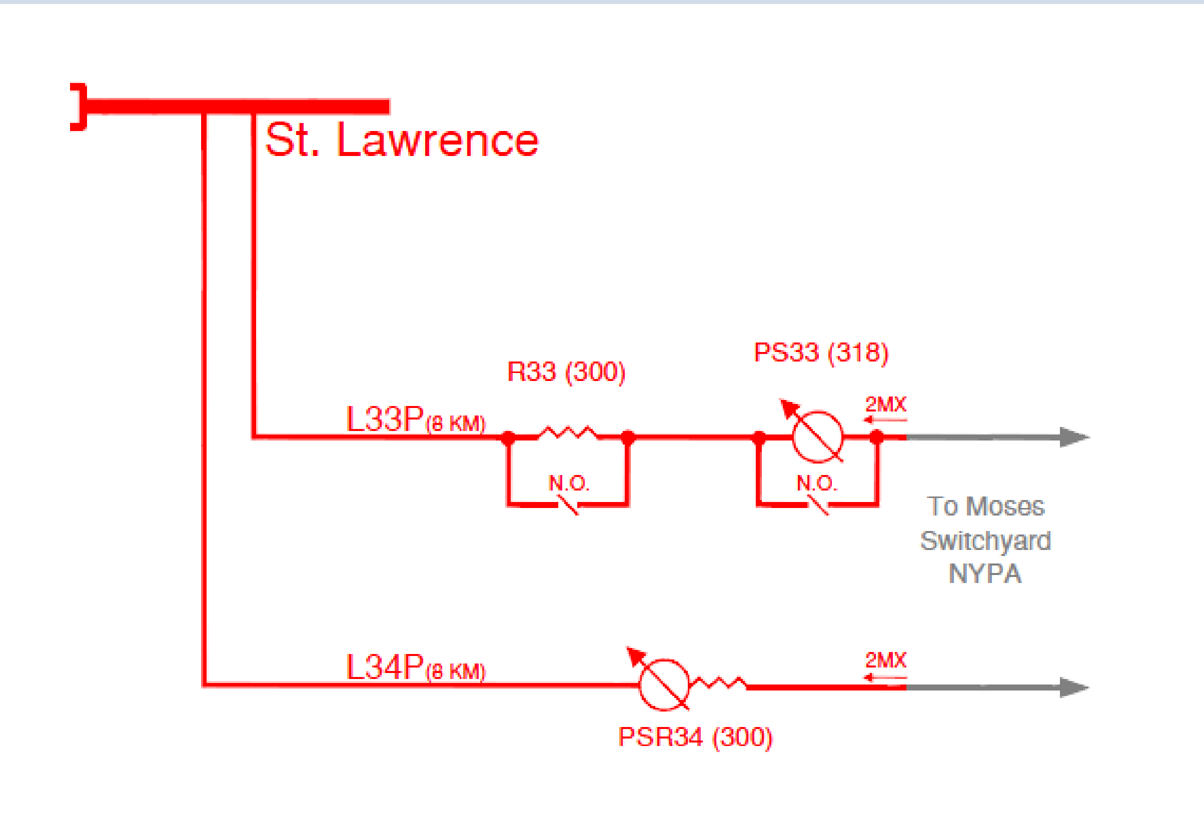
Section 1.

Identify the PARs that have the ability to alter flows around Lake Erie and should be included in the coordination study.

Response:

The following PARs are located on the Ontario-New York (Adirondack) Interface.

Physically installed within Ontario:
St. Lawrence PS33 (on circuit L33P)
St. Lawrence PSR34 (on circuit L34P)



Section 2.

Identify the operating characteristics of each device:

A. Review the historical operation of these devices and identify their expected future operation:
   1. Describe how they are operated on a daily, hourly and monthly basis and variations in the operation that are time or system conditions dependent.

Response:

St. Lawrence PS33 & PSR34 (L33P/L34P)

- Regularly used to alleviate post-thermals on both the Ont-Mich and Ont-NY interfaces (most active of all phase-shifters)
- Loop Flow along with schedule changes between IESO-HQTE and NYISO-HQTE will have a significant impact on this interface. As a result, phase-shifters frequently run out of tap room.
- Approx 10% of the flow change at St. Lawrence will be reflected on the NY-Niagara Interface
- Tap changes are discussed between IESO-NYISO prior to making adjustments

2. Describe the objectives that are trying to be met and how successful the devices are at meeting these objectives.

Response:

The objective of these devices is to regulate the flow to a determined amount.

B. Describe the physical characteristics associated with the operation of each device:
   1. Does the device operate in an automatic mode to meet the objectives or does it rely on manual intervention on a one-time or continuous basis?

Response:

There is no automatic phase-shifting capability on any of these phase shifters. Manual intervention is needed, however only as required. All parties involved strive to meet objectives met by this equipment on a pro-active basis. For example, if large interchange schedules are anticipated to create thermal restrictions, any tap changes required to alleviate these concerns would be done so in advance of the schedule changes.

2. What are the equipment restrictions and the system restrictions that affect device operations?

Response:

Equipment restrictions consist of:

- thermal ratings of the devices
- angle capability (total range and discrete tap positions)
- duty cycle (frequency and total changes) on the tap changers

Thermal ratings and angle capabilities are provided below. Duty cycles are not available.

MVA Ratings of New York-Ontario Tie Line Phase shifters

Tie	kV (1)	Summer			Winter		
		Continu-ous	LTE (3)	STE	Continu-ous	LTE (3)	STE
PS33:(2) 16° shift	240	318	340	525	372	395	561
29.5° shift		300	324	441	356	378	480
40° shift		240	259	334	285	298	363
PSR34:(2) 0° shift		331	372	524	393	415	580
20° shift	240	319	357	504	378	399	558
40° shift		300	336	474	356	375	525

Notes: (1) Convert to MVA ratings to amperes on kV base indicated.

(2) Ratings for the phase shifters are symmetric with respect to shift angle. Use straight line interpolation for ratings at other phase shift angles.

(3) LTE ratings are valid for up to four cumulative hours during any 24-hour period.

New York-Ontario Tie Circuit Energization, and Voltage & Angle Taps

Tie	Energize From	Voltage Taps	Angle Taps
L33P	New York	33 tap LTC down MX out	19 tap LTC down MW out
L34P	New York	33 tap LTC down MX out	33 tap LTC down MW out

3. Is there a change in state from where the device is regulating to meet the objective function to where the device is not longer able to regulate (i.e. a PAR being operated at one end of a tap range)?

Response:

There is no change of state. This is like any other transformer. They can be adjusted to either their top or bottom tap position, beyond which there is no further capability to make an adjustment.

When the PAR is "out of tap room" – either on its bottom or top tap position, it basically becomes free flowing with an impedance corresponding to either the top or the bottom tap respectively.

C. Does an operating guide, procedure or contractual arrangement exist that defines the operation of the device? Is there any flexibility in the use of this device or other devices to meet the objective function?

Response:

NYISO-IMO-C01-R2: Principles of Operation for the NY-Ont Interconnection & Associated Facilities

NYISO-IESO-C02-R4: Security Criteria Applicable to NY-Ont Interconnection

IESO Market Manual 7.4 – IESO Controlled Grid Operating Policies:

http://www.ieso.ca/imoweb/pubs/systemOps/so_GridOpPolicies.pdf

IESO Internal Manual 2.4-7 – Interchange Operations

Chapter 5 of the Market Rules for Ontario:

http://www.ieso.ca/imoweb/pubs/marketRules/mr_chapter5.pdf

[Also see response to #2 in section 3 below]

D. Market impact of expected PAR schedules:
   1. Are these devices responsive to market conditions? Is their operation reflected in the market solution? Will the market solution try to adjust the device to optimize the market solution or are the devices responsive to price signals sent by the market?

Response:

The devices are responsive to market conditions. They can be used to control flows to economic schedules. As such, their operation can be reflected in the market (dispatch) solution.
The market solution can adjust the flows to achieve various objectives/outcomes, including economic schedules, or targeted flows.

The devices are not directly responsive to price signals. [*We do not believe that any PARs are responsive to price signals — we are not sure what would the associated objective function would look like.*]

For additional details see response to #2 below.

2. How are operation of these devices modeled in the day-ahead market and the real-time market? Are there market challenges associated with the operation of these devices (i.e. interface pricing)?

Response:

Ontario's dispatch algorithm (which produces the actual system dispatch instructions) does not take tap position into consideration when scheduling. The calculations, however, factor in the targeted controlled flows, and these can be set to match the economic schedule.

In our "pre-dispatch" calculations, anticipated targeted flows are manually applied to each phase shifter based on:

- The average expected direction and magnitude of ONT-NY schedules for the next day/hour.
- Anticipated Loop Flow
- Anticipated impact of other schedules (ie: ONT-HQ and NY-HQ schedules)
- Each phase-shifter is usually set to share half of what is expected flow at the St. Lawrence interface.

In the IESO's real-time calculations, actual flows (acquired from telemetry) are manually applied to each phase-shifter in the dispatch model.

The capability exists for the phase-shifters to have their targeted flows distributed automatically by the dispatch algorithm in both the pre-dispatch and real-time time frames. The amount for each would be based on the total interchange schedule between ONT and NY and would be distributed on a pro-rata basis depending on their thermal ratings.

For obvious reasons, there is much greater accuracy in our real-time calculations. The need for manual intervention and forecast inaccuracies in the pre-dispatch calculations can create dispatch anomalies in real-time. It can also lead to under/over scheduling situations on the interface.

Section 3.

Identify how operations of the devices impact Lake Erie loop flow:

A. Identify flowgates around Lake Erie that are impacted by each device:

Response:

BLIP
NBLIP
IMO-MECS
MECS-IMO
NY-IMO
IMO-NY

Frontier-IMO
IMO-Frontier
IMO-Adirondack
Adirondack-IMO
QFW
FETT

1. Is there a way to measure these impacts in both real-time and on an after-the-fact basis? Are there existing tools that can be used to measure the impact of each device or are new tools needed?

Response:

As for methods for measuring the Lake Erie Circulation impacts of these PARs in both real-time and on an after-the fact basis, the NPCC-RFC working group can estimate the impact using their seasonal study models. System operators can normally accomplish this by adjusting the PARs of interest and keeping all else constant. It is difficult to study and measure PAR impact on Lake Erie Circulation due to the difficulty of isolating the effect of adjusting the PARs in a dynamic system such as in real-time. Currently, tools do not exist to measure the impacts to Lake Erie circulation of PARs that are not conforming schedule to actual flows, although tools could be developed.

2. Under what circumstances would this device add to or reduce loop flow?

Response:

In accordance with agreements, the PARs are expected to be used to adjust flows closer to dispatch (normal mode), or directed to be off-schedule (i.e. offset), for assisting in managing reliability in other parts of the system. Specifically, the New York – Ontario operating agreement states:

- The phase shifters may be moved by mutual consent to permit increased interconnection transactions between Ontario and New York and to make the most efficient use of New York-Ontario interface capacity, providing all relevant Operating Security Limits are observed.

- In the absence of a mutual agreement, the party whose internal transmission is loaded by the flow on L33P and L34P may direct the setting of the phase angle regulators to be placed at any tap which results in reduced loading of L33P and L34P to as little as zero MW flow.

Appendix D – MEN November 1999 Study

Included in separate attachment

Appendix E – Scenarios for Data Analysis

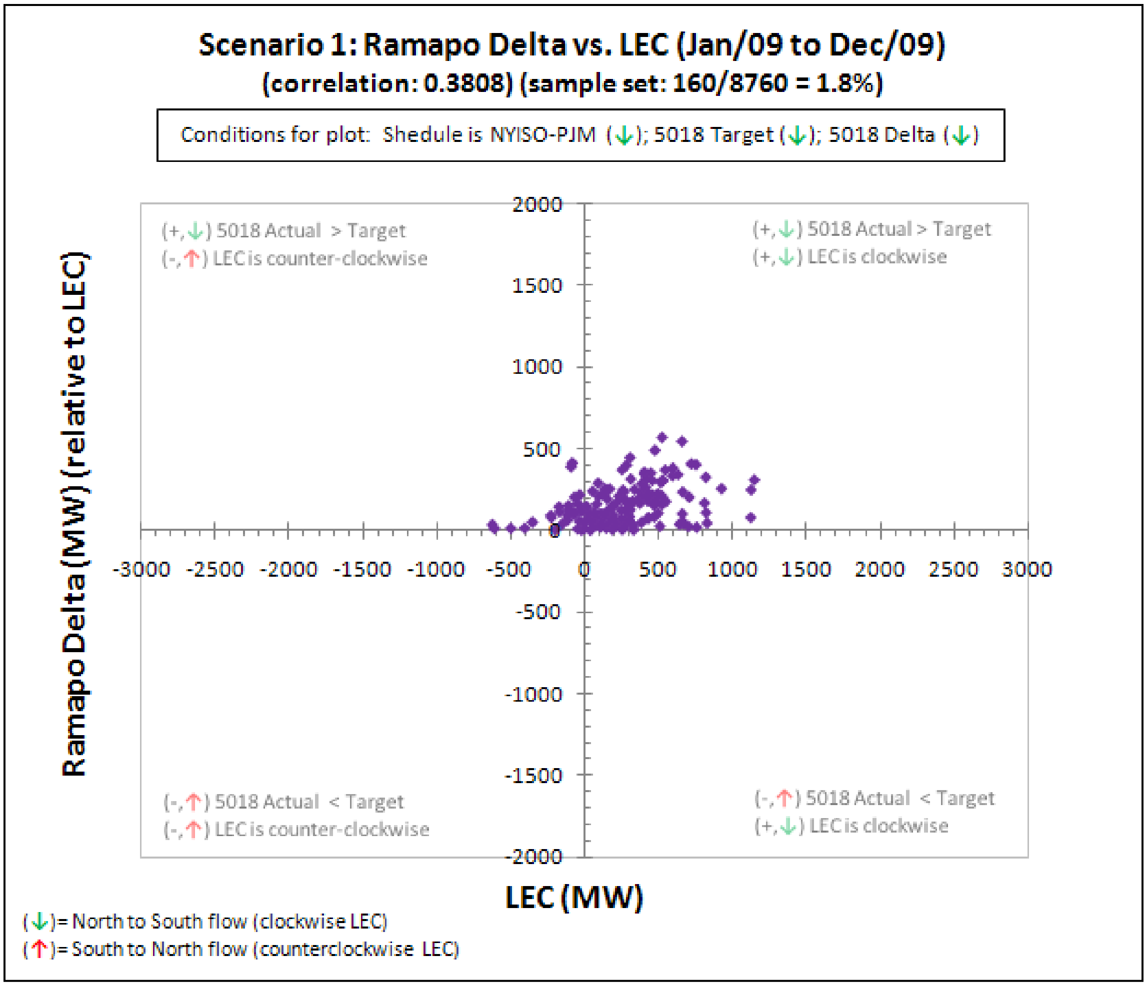
Several different scenarios were considered while determining where significant correlations might exist for the data gathered. Three specific parameters were considered when developing the scenarios. The first parameter was the direction of scheduled interface flows between PJM and NYISO. The second parameter was the direction of the target flow for the Branchburg-Ramapo (5018) line. The third parameter was the direction of the delta flow for the Branchburg-Ramapo (5018) line. Table 2 Scenario and Parameters Summary of the report summarizes the scenarios that the study group analyzed. Scenario 3&4 and Scenario 7&8 were found to have a strong positive correlation and are included in the body of the report. Scenarios 1, 3, 6, and 7 were determined to have a weak correlation and Scenarios 2, 4, 5 and 8 were determined to have some positive correlation and are included in Appendix E for reference.

Table 2 Scenarios and Parameter Summary

Scenarios	Direction of Schedules for PJM-NYISO Interface	Target Flow: Branchburg-Ramapo (5018)	Delta Flow: Branchburg-Ramapo (5018)	Correlation:	Data set size (8760 total)	(%)
1	NYISO-PJM ↓	NYISO-PJM ↓	NYISO-PJM ↓	0.3808	160	1.8%
2	NYISO-PJM ↓	NYISO-PJM ↓	PJM-NYISO ↑	0.5773	507	5.8%
3	NYISO-PJM ↓	PJM - NYISO ↑	PJM-NYISO ↑	0.4316	28	0.3%
4	NYISO-PJM ↓	PJM - NYISO ↑	NYISO-PJM ↓	0.5257	30	0.3%
3 & 4	NYISO-PJM ↓	PJM - NYISO ↑		0.7188	58	0.7%
5	PJM - NYISO ↑	PJM - NYISO ↑	PJM - NYISO ↑	0.5129	2768	31.6%
6	PJM - NYISO ↑	PJM - NYISO ↑	NYISO-PJM ↓	0.3497	3624	41.4%
7	PJM - NYISO ↑	NYISO-PJM ↓	NYISO-PJM ↓	0.2707	731	8.3%
8	PJM - NYISO ↑	NYISO-PJM ↓	PJM - NYISO ↑	0.5000	912	10.4%
7 & 8	PJM - NYISO ↑	NYISO-PJM ↓		0.6196	1643	18.8%
				Points captured in plots	8760	100.0%

Scenario 1 displays the Ramapo Delta vs. LEC with conditions described below:

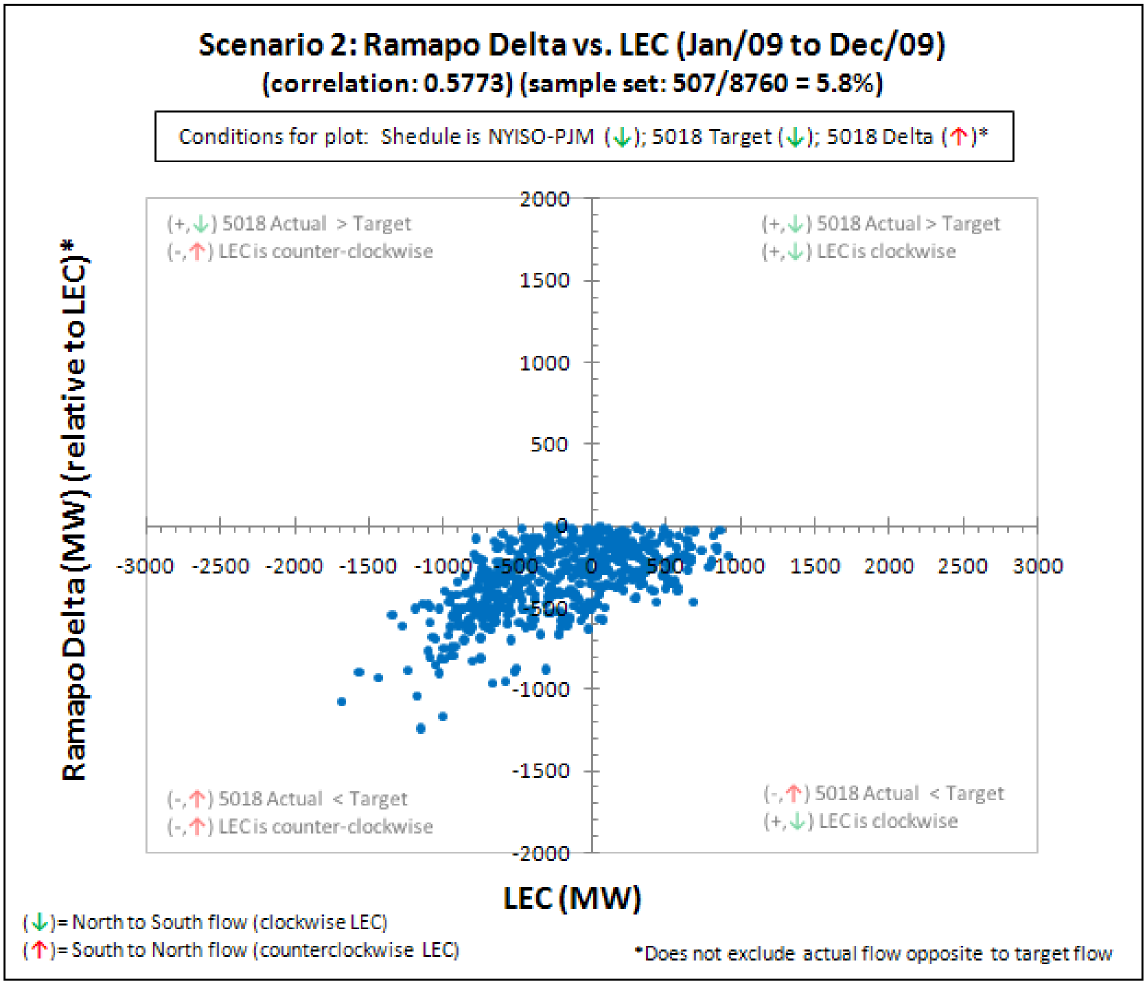
- Interface Schedules for PJM-NYISO: Schedule is flowing from NYISO to PJM (↓)
- Target flow on the Branchburg-Ramapo line: Target flow is from NYISO to PJM (↓)
- Delta flow on the Branchburg-Ramapo line: Delta flow is from NYISO to PJM (↓)



Scenario 1: Ramapo Delta vs. LEC (Jan/09 to Dec/09)

Scenario 2 displays the Ramapo Delta vs. LEC with conditions described below:

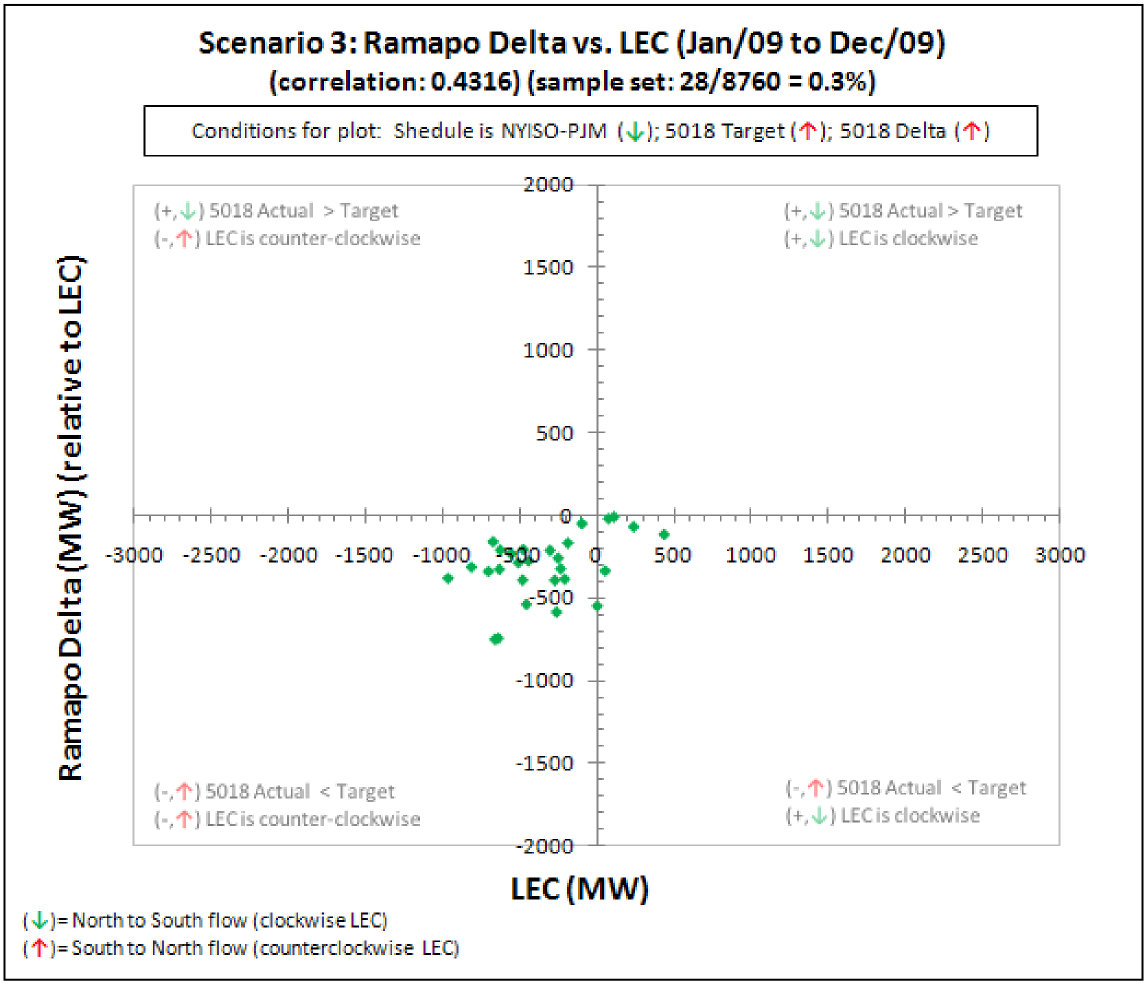
- Interface Schedules for PJM-NYISO: Schedule is flowing from NYISO to PJM (↓)
- Target flow on the Branchburg-Ramapo line: Target flow is from PJM to NYISO (↓)
- Delta flow on the Branchburg-Ramapo line: Delta flow is from NYISO to PJM (↑)



Scenario 2: Ramapo Delta vs. LEC (Jan/09 to Dec/09)

Scenario 3 displays the Ramapo Delta vs. LEC with conditions described below:

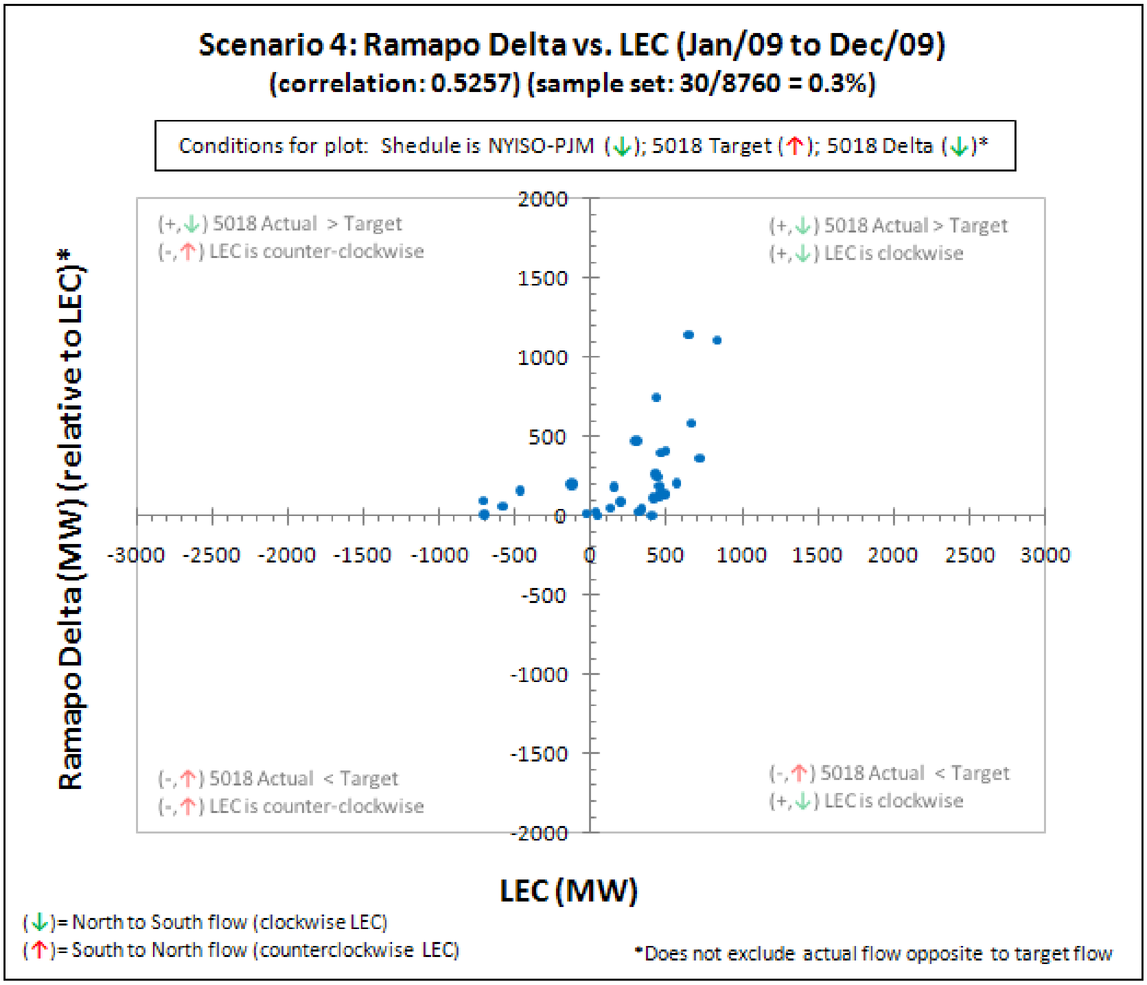
- Interface Schedules for PJM-NYISO: Schedule is flowing from NYISO to PJM (↓)
- Target flow on the Branchburg-Ramapo line: Target flow is from PJM to NYISO (↑)
- Delta flow on the Branchburg-Ramapo line: Delta flow is from PJM to NYISO (↑)



Scenario 3: Ramapo Delta vs. LEC (Jan/09 to Dec/09)

Scenario 4 displays the Ramapo Delta vs. LEC with conditions described below:

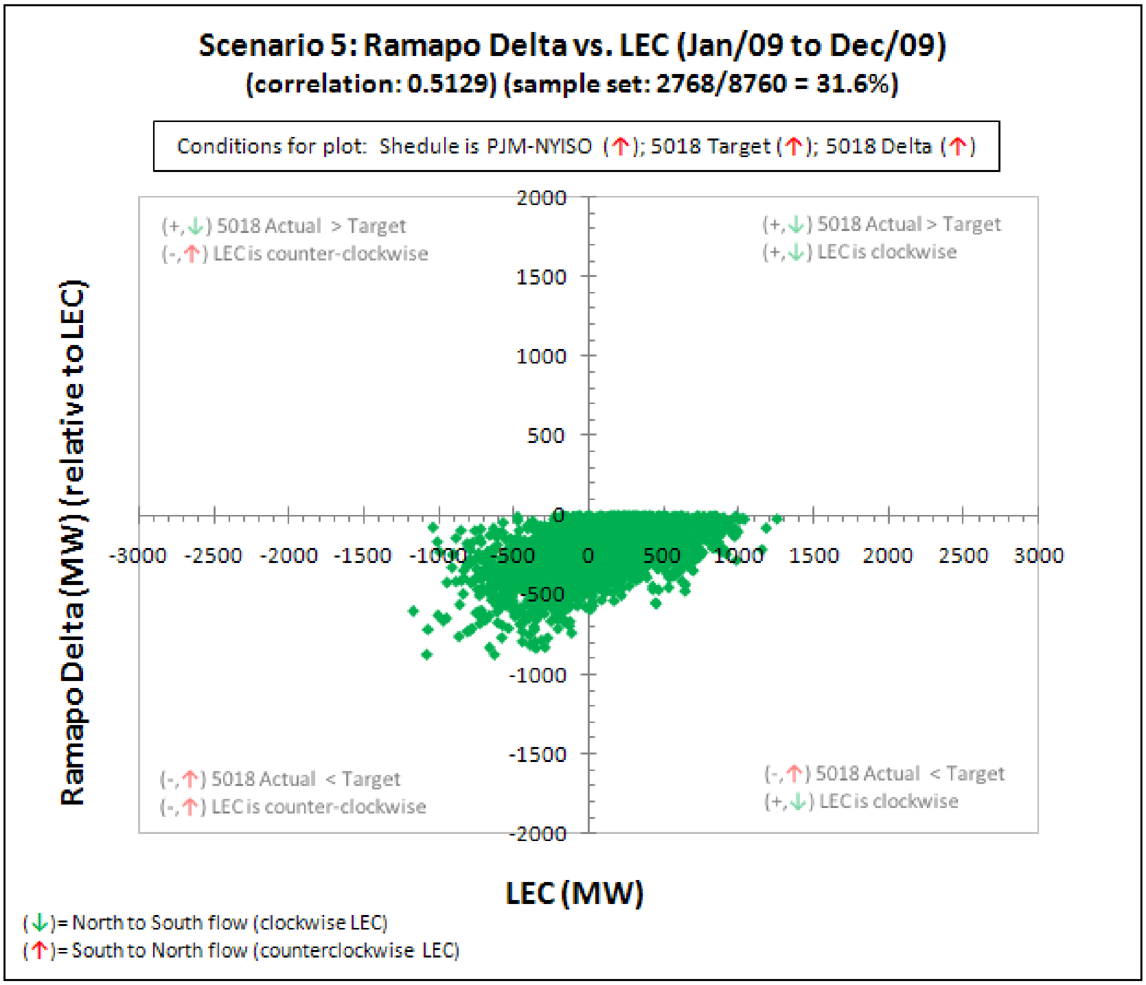
- Interface Schedules for PJM-NYISO: Schedule is flowing from NYISO to PJM (↓)
- Target flow on the Branchburg-Ramapo line: Target flow is from PJM to NYISO (↑)
- Delta flow on the Branchburg-Ramapo line: Delta flow is from NYISO to PJM (↓)



Scenario 4: Ramapo Delta vs. LEC (Jan/09 to Dec/09)

Scenario 5 displays the Ramapo Delta vs. LEC with conditions described below:

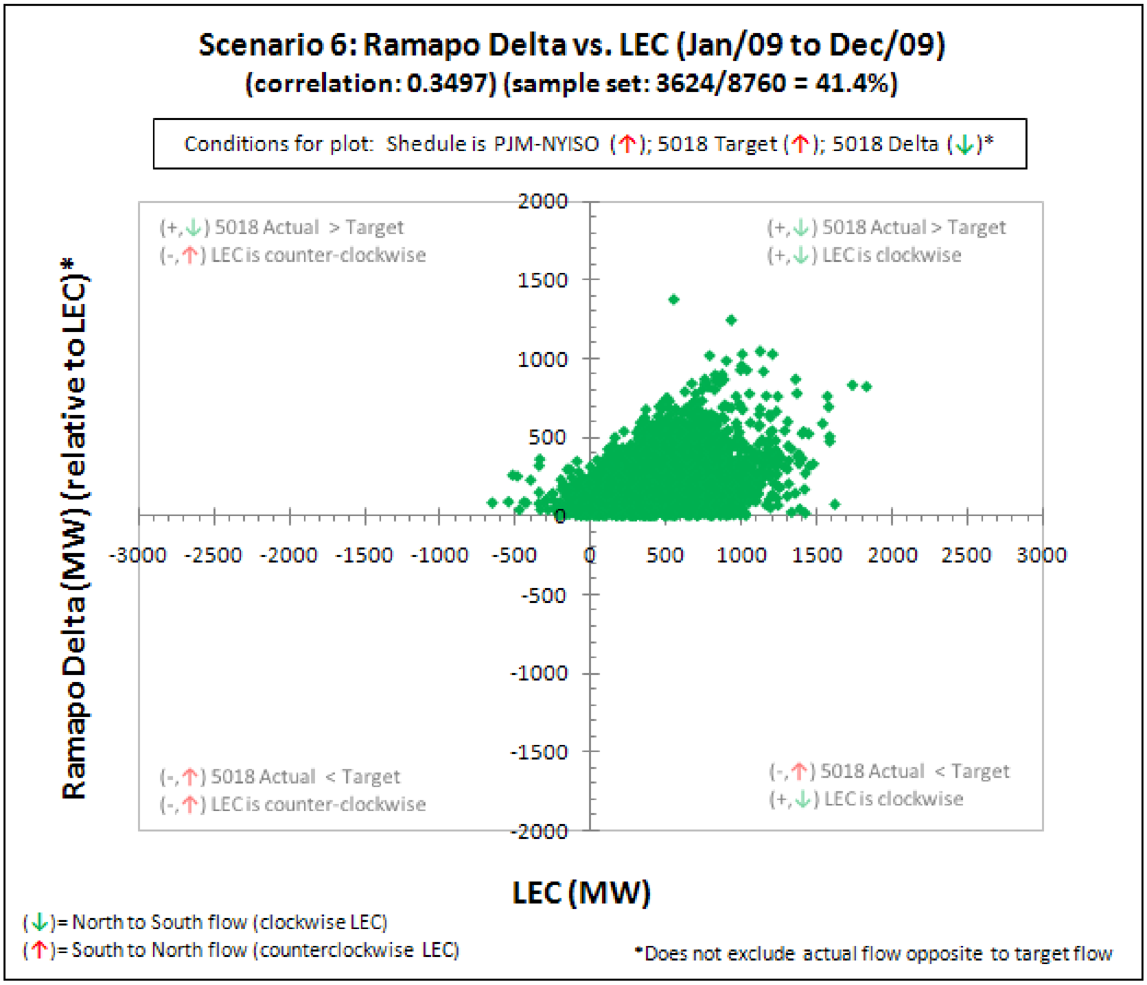
- Interface Schedules for PJM-NYISO: Schedule is flowing from PJM to NYISO (↑)
- Target flow on the Branchburg-Ramapo line: Target flow is from PJM to NYISO (↑)
- Delta flow on the Branchburg-Ramapo line: Delta flow is from PJM to NYISO (↑)



Scenario 5: Ramapo Delta vs. LEC (Jan/09 to Dec/09)

Scenario 6 displays the Ramapo Delta vs. LEC with conditions described below:

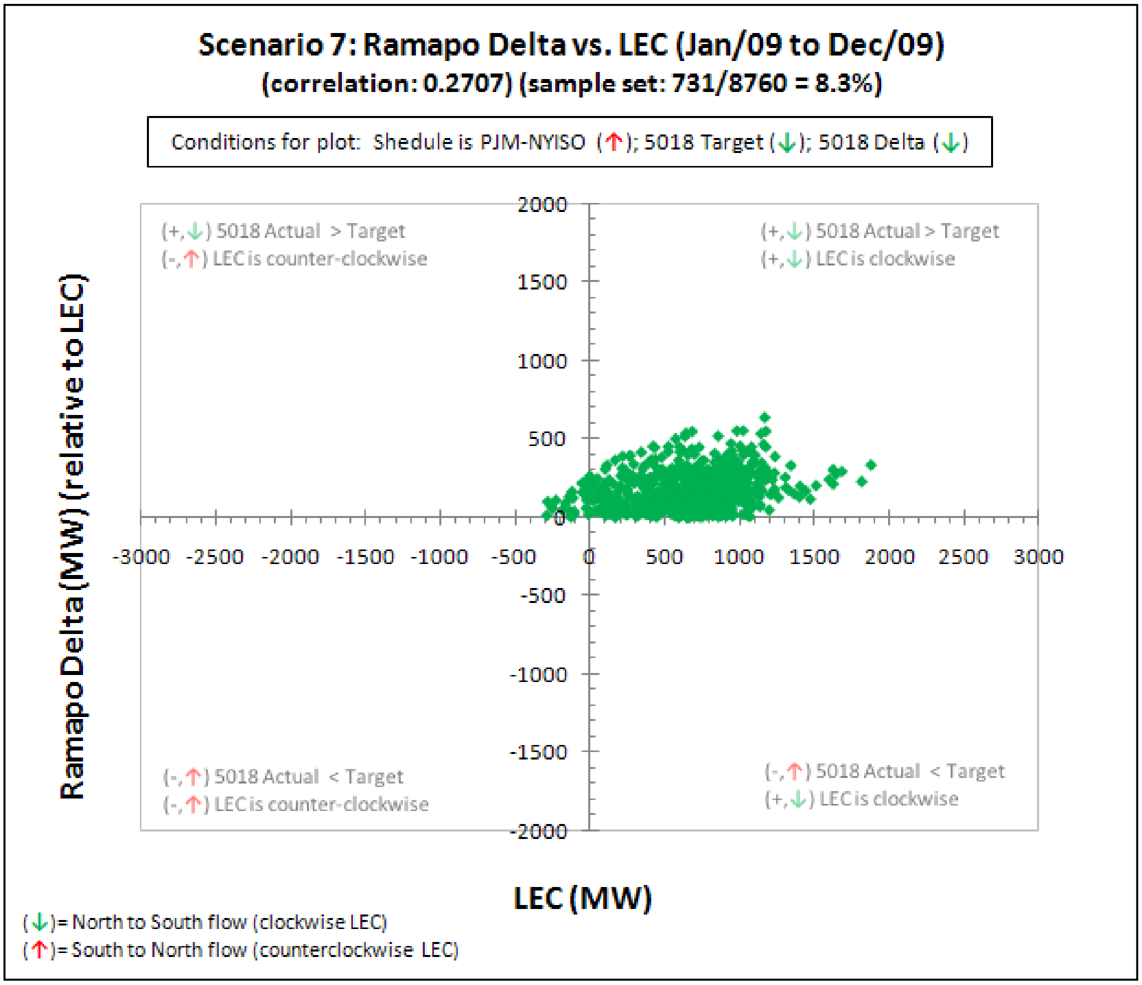
- Interface Schedules for PJM-NYISO: Schedule is flowing from PJM to NYISO (↑)
- Target flow on the Branchburg-Ramapo line: Target flow is from PJM to NYISO (↑)
- Delta flow on the Branchburg-Ramapo line: Delta flow is from NYISO to PJM (↓)



Scenario 6: Ramapo Delta vs. LEC (Jan/09 to Dec/09)

Scenario 7 displays the Ramapo Delta vs. LEC with conditions described below:

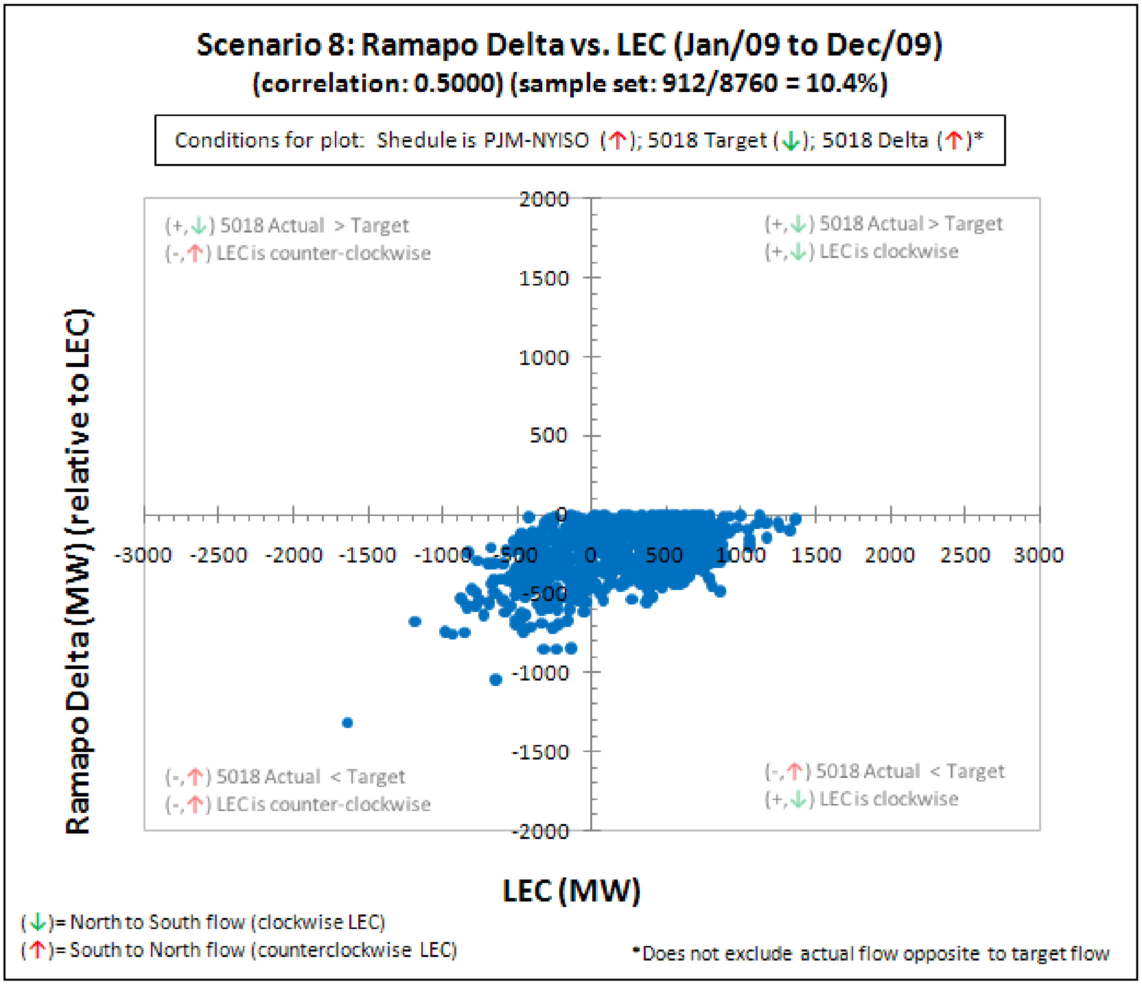
- Interface Schedules for PJM-NYISO: Schedule is flowing from PJM to NYISO (↑)
- Target flow on the Branchburg-Ramapo line: Target flow is from NYISO to PJM (↓)
- Delta flow on the Branchburg-Ramapo line: Delta flow is from NYISO to PJM (↓)



Scenario 7: Ramapo Delta vs. LEC (Jan/09 to Dec/09)

Scenario 8 displays the Ramapo Delta vs. LEC with conditions described below:

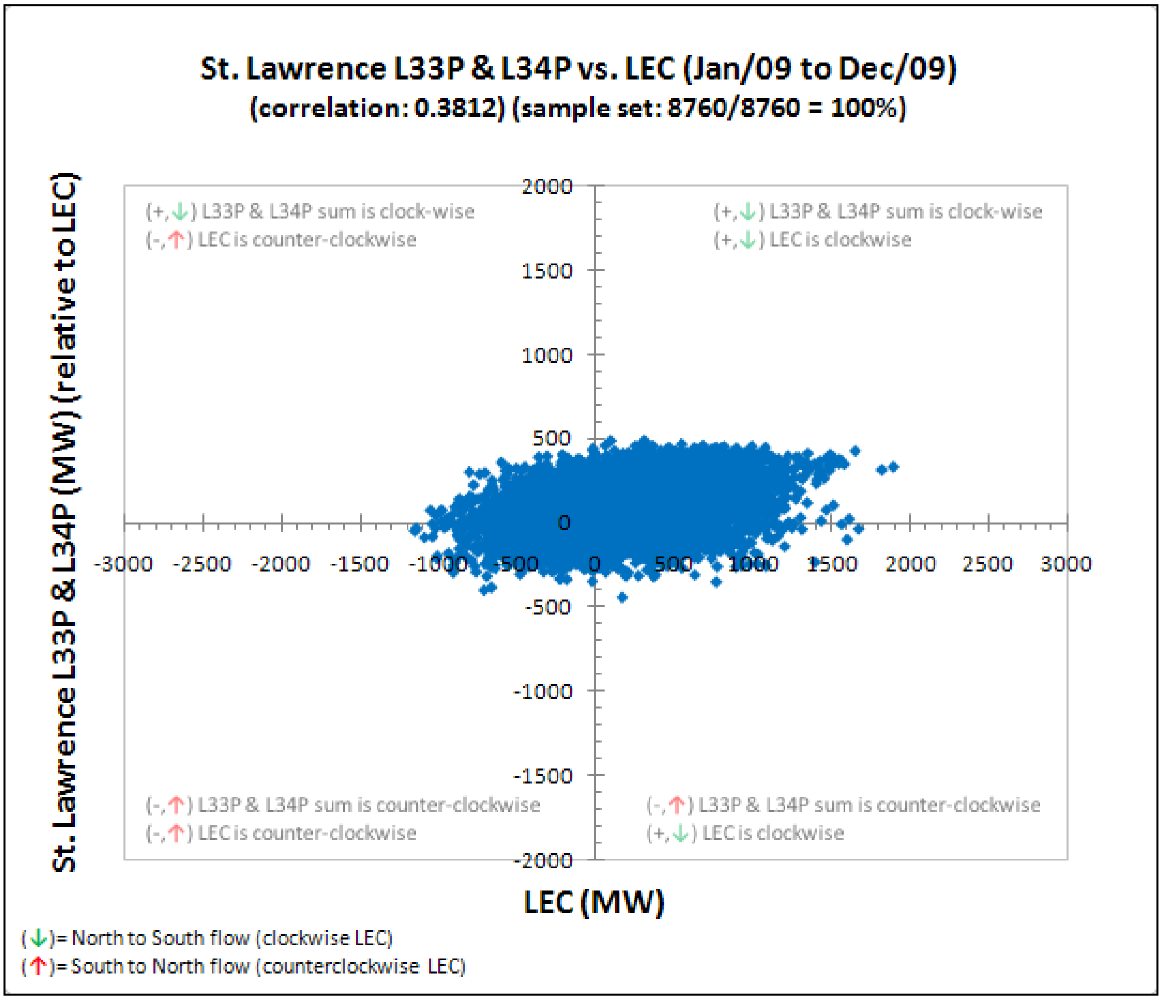
- Interface Schedules for PJM-NYISO: Schedule is flowing from PJM to NYISO (↑)
- Target flow on the Branchburg-Ramapo line: Target flow is from NYISO to PJM (↓)
- Delta flow on the Branchburg-Ramapo line: Delta flow is from PJM to NYISO (↑)



Scenario 8: Ramapo Delta vs. LEC (Jan/09 to Dec/09)

Scenario 9 displays the St. Lawrence PAR flow vs. LEC with conditions described below:

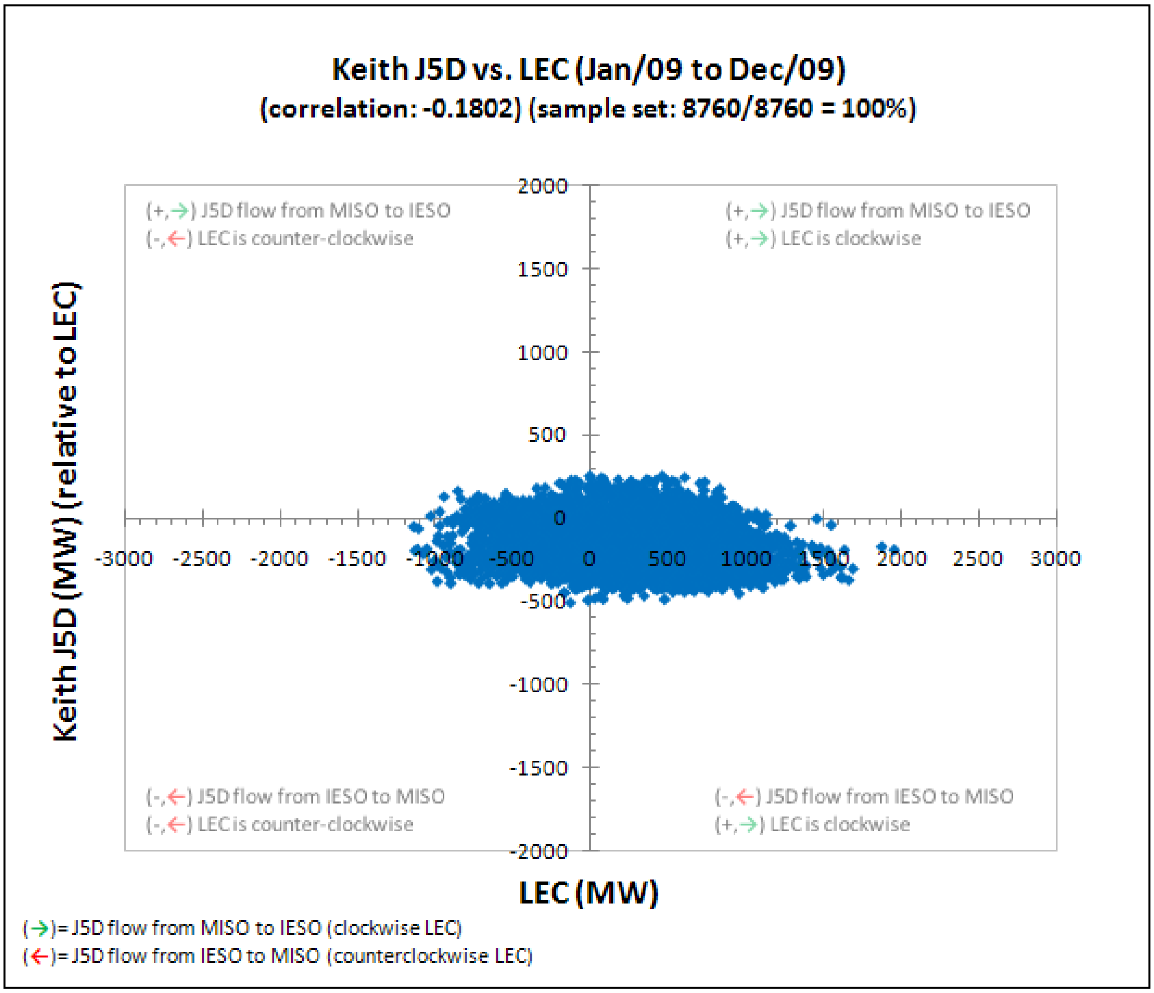
- There is no defined target flow on an hourly basis for the St. Lawrence PARs, hence only actual flow across the St. Lawrence PAR is analyzed with LEC.



Scenario 9: St. Lawrence PAR flow vs. LEC (Jan/09 to Dec/09)

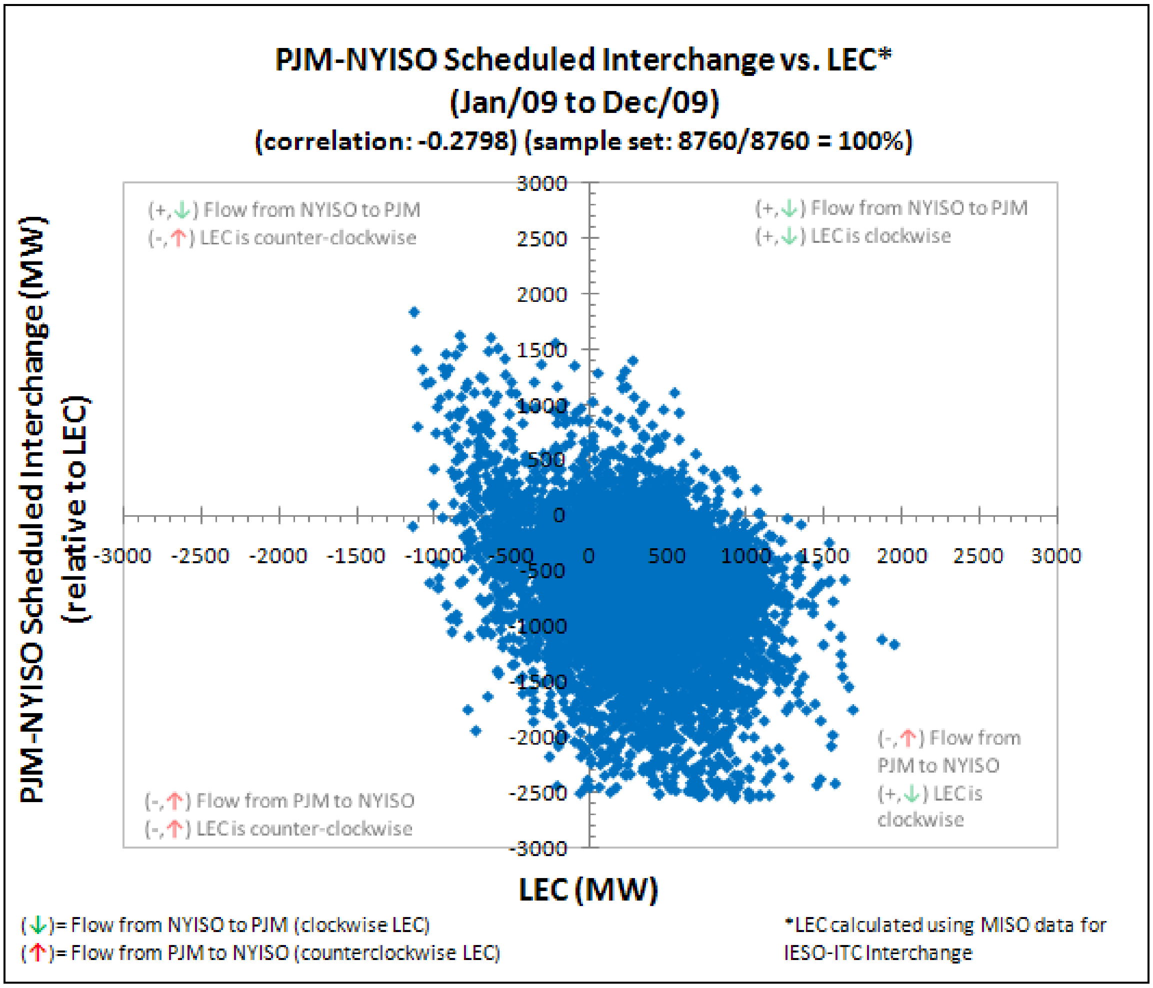
Scenario 10 displays the J5D PAR flow vs. LEC with conditions described below:

- There is no defined target flow on an hourly basis for the J5D PAR, hence only actual flow across the J5D PAR is analyzed with LEC.

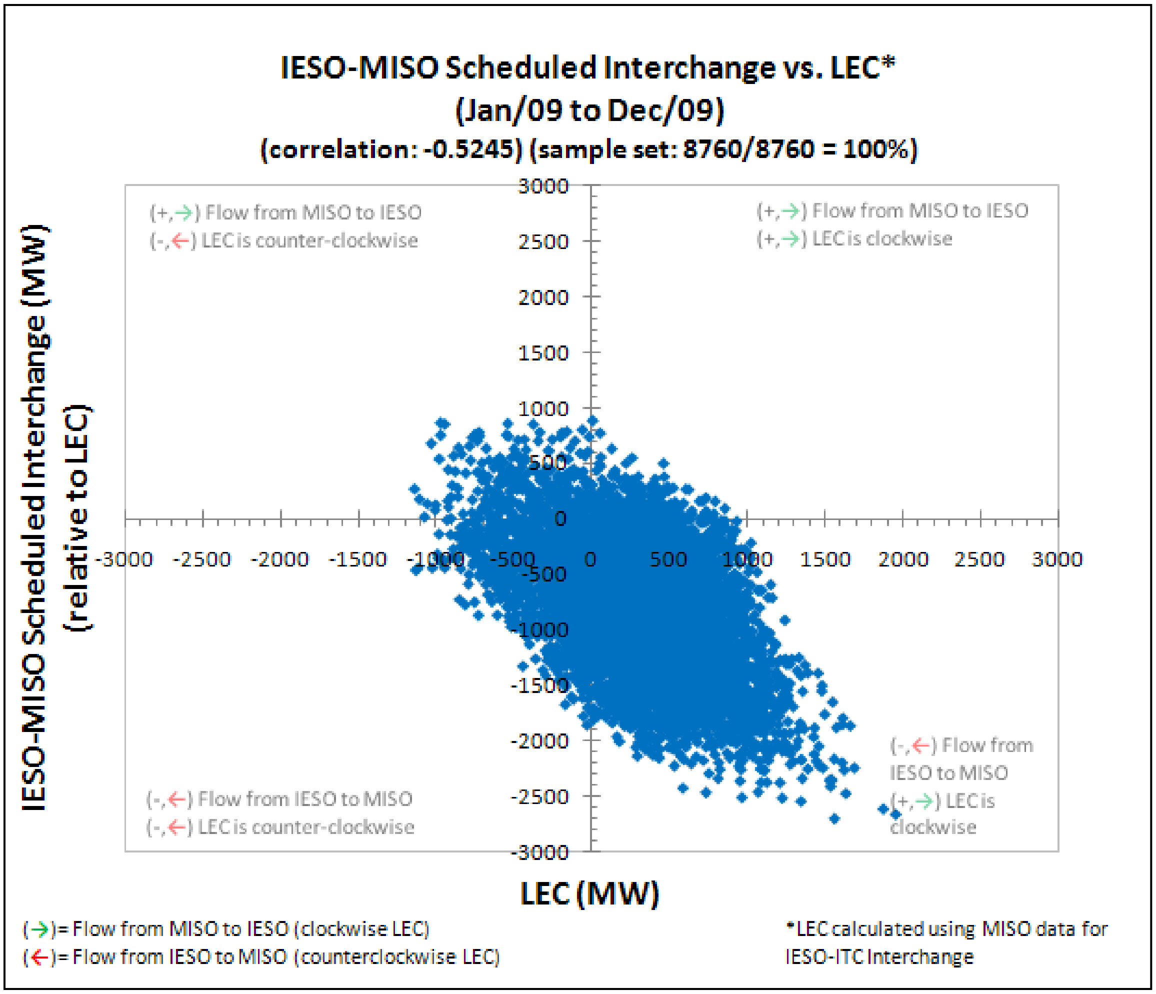


Flow Indicator	Relative Sign	Color Denotes	Direction of arrow Denotes
↓←↑→	+	clockwise LEC (green)	direction of flow for the interface (positive)
↓←↑→	-	counterclockwise LEC (red)	direction of flow for the interface (negative)

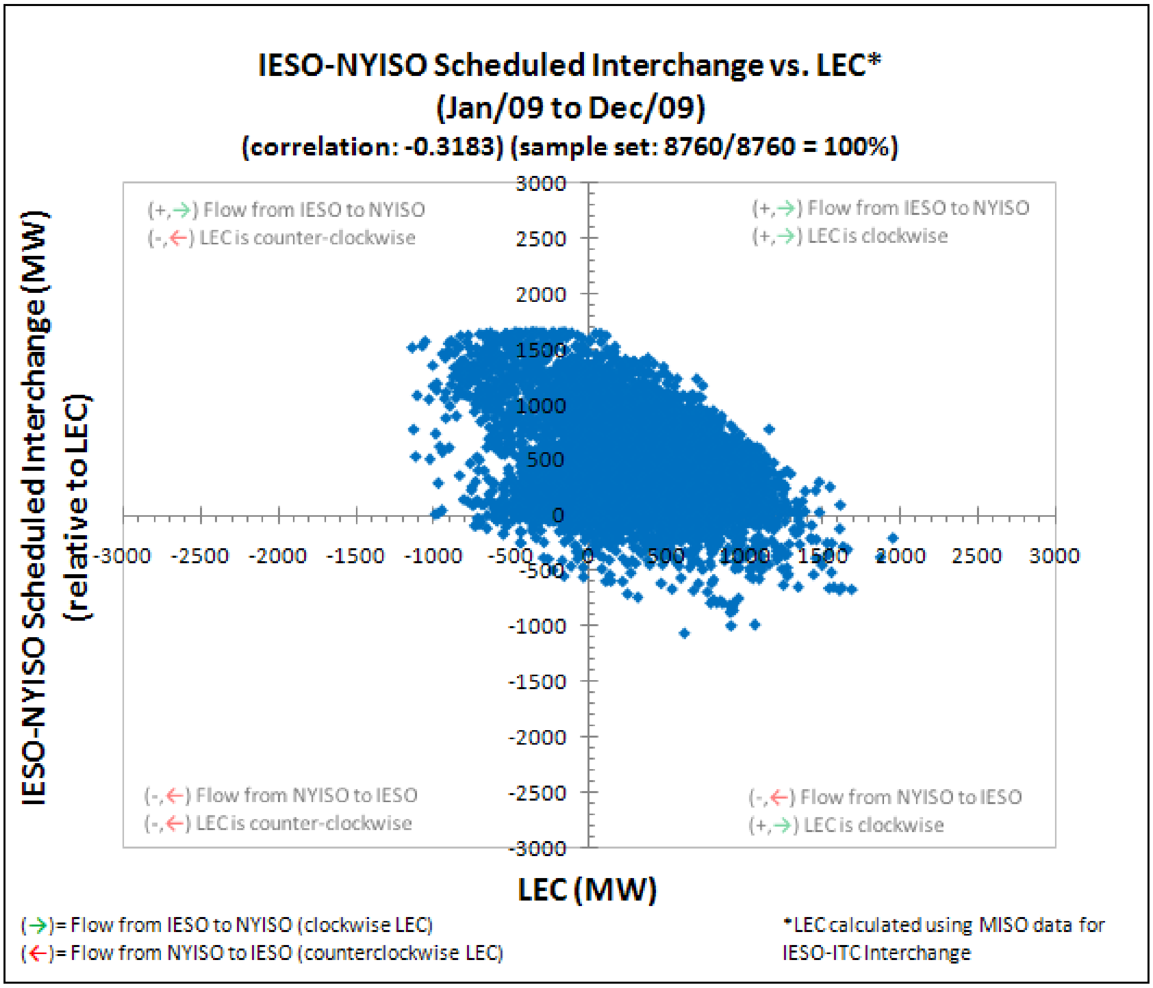
Scenario 10: J5D PAR flow vs. LEC (Jan/09 to Dec/09)



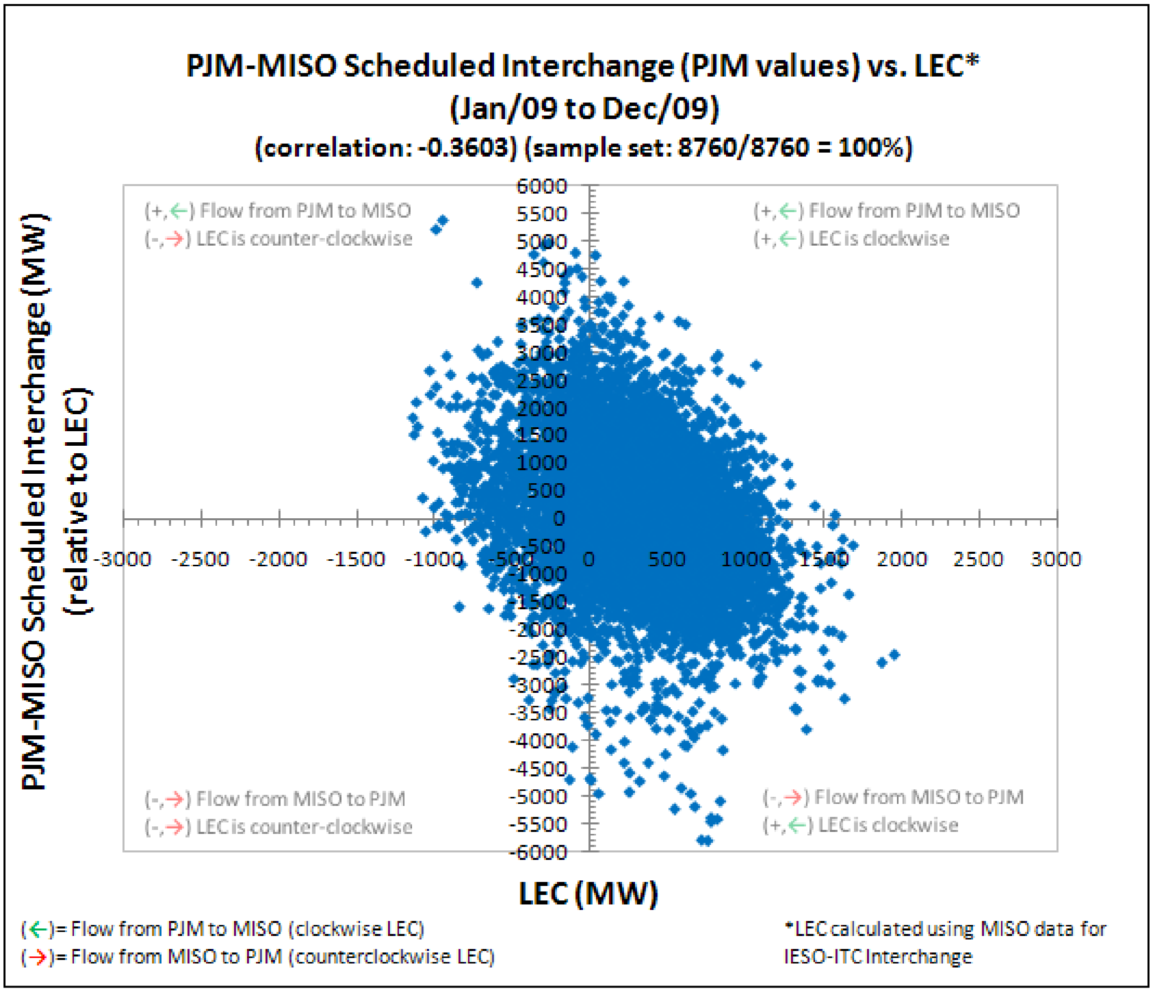
Scenario 11: PJM-NYISO Scheduled Interchange vs. LEC (Jan/09 to Dec/09)



Scenario 12: IESO-MISO Scheduled Interchange vs. LEC (Jan/09 to Dec/09)



Scenario 13: IESO-NYISO Scheduled Interchange vs. LEC (Jan/09 to Dec/09)



Scenario 14: PJM-MISO Scheduled Interchange vs. LEC (Jan/09 to Dec/09)

Appendix F - Correlation Analysis using Excel[4]

The correlation coefficient allows researchers to determine if there is a possible linear relationship between two variables measured on the same subject (or entity). When these two variables are of a continuous nature (they are measurements such as weight, height, length, *etc*.) the measure of association most often used is Pearson's correlation coefficient.

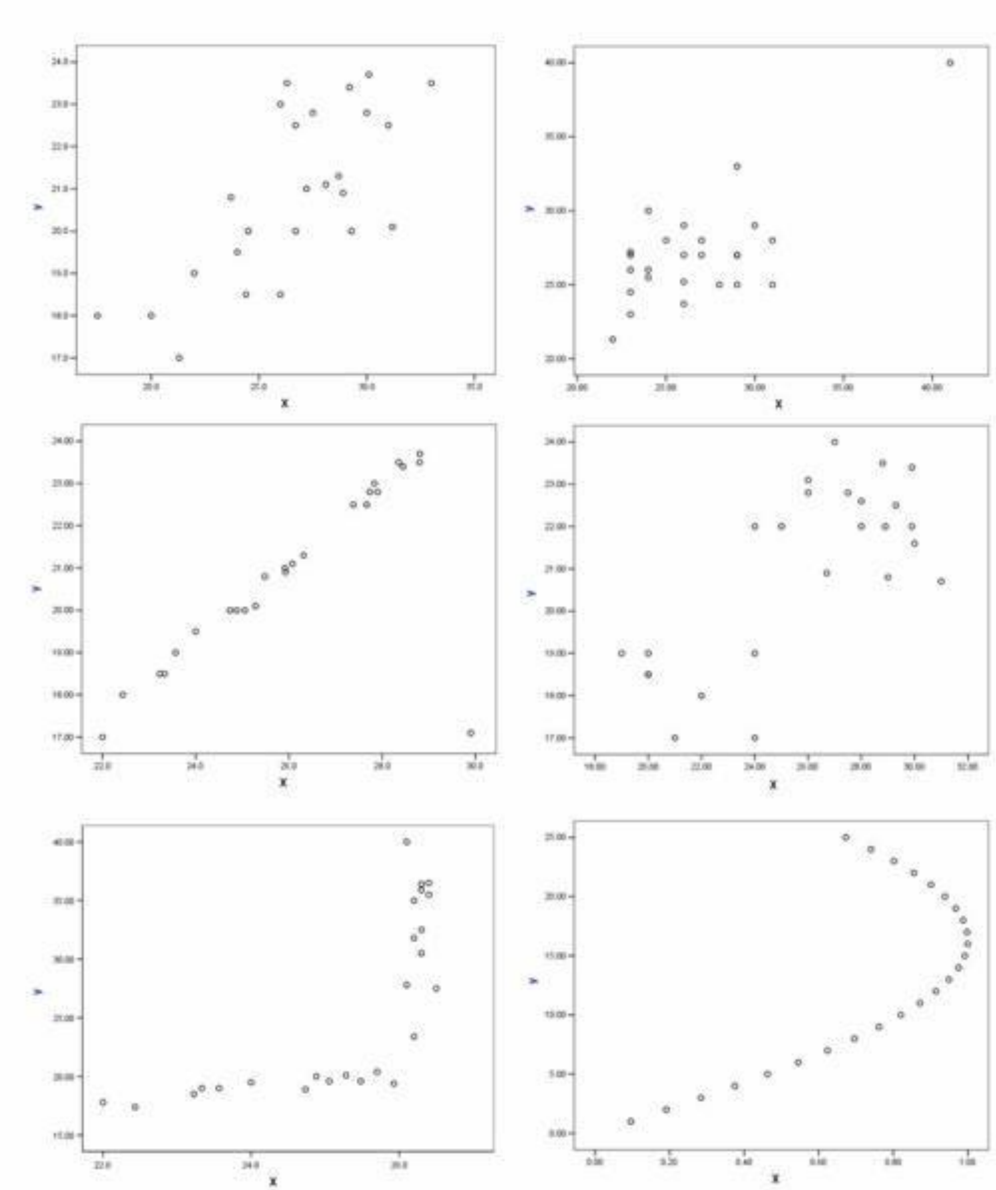
This association may be expressed as a number (the correlation coefficient) that ranges from –1 to +1. The population correlation is usually expressed as the Greek letter *rho* (r) and the sample statistic (correlation coefficient) is r.

The correlation measures how well a straight line fits through a scatter of points when plotted on an x – y axis. If the correlation is positive, it means that when one variable increases, the other tends to increase. If the correlation is negative, it means that when one variable increases, the other tends to decrease. When a correlation coefficient is close to +1 (or –1), it means that there is a strong correlation – the points are scattered along a straight line. For example, a correlation $r = 0.7$ may be considered strong. However, the closer a correlation coefficient gets to 0, the weaker the relationship, where the cloud (scatter) of points is not close to a straight line. For example, a correlation $r = 0.1$ might be considered weak. For scientific purposes, a t-test is utilized to determine if the correlation coefficient is "strong" or "significant" or not.

Assumptions: Before using the Pearson correlation coefficient as a measure of association, you should be aware of its assumptions and limitations. As mentioned earlier, this correlation coefficient measures a *linear* relationship. That is, the relationship between the two variables measures how close the two measurements form a straight line when plotted on an x-y chart. Therefore, it is important that data be graphed before the correlation is interpreted. For example, it is possible that data, when plotted, may show a curved relationship instead of a straight line. When this is the case, a Pearson correlation may not be the best measure of association. There are other conditions when a correlation coefficient may appear important, but when considered in light of a graph, is not a good measure of relationship. In the following graphs, all of them have a correlation coefficient of about 0.72, yet most do not fit the assumption of a linear relationship. To avoid misinterpreting a correlation, always accompany the calculation with a graph.

Another assumption of correlation is that the both of the variables (the measurements) be of continuous data measured on an interval/ratio scale. Data that are not continuous, such as categorical (i.e. hair color) or binomial (i.e., gender) data would not be acceptable. Also, each variable should be approximately normally distributed.

[4] "Correlation Analysis using Excel," Excel Tutorials for Statistical Data Analysis, 2008. 31 January 2011 < http://www.stattutorials.com/EXCEL/EXCEL-pearson-correlation.html>.



Appendix G – Scope of Regional Power Control Device Coordination Study

Objective

Identify the devices that have the ability to alter Lake Erie loop flow, fully understand how these devices are being operated currently and how they contribute to Lake Erie loop flow based on this operation, and determine how they can be used to manage Lake Erie loop flow on a coordinated basis.

Background

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 use of PARs will alter the flows to follow a different electrical path. There are a number of operating limitations that prevent the use of PARs to eliminate circulation flows. Since uncoordinated operation of the PARs could increase circulation flows, it is important that coordinated operation of PARs by the four markets around Lake Erie be considered in the long term solutions to loop flows. In addition to PARs, variable frequency transformers, series capacitors, and other such devices have the ability to alter flows that should also be included in this solution to loop flows.

The PARs that operate around Lake Erie include the PJM and NYISO interface ties at Waldwick (JK), Linden and Hudson (ABC) and Ramapo, the NYISO and IESO interface ties at St. Lawrence and the IESO-MP and IESO-MH interface ties. Of the four ties between MECS and IESO, 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 replacement B3N PARs have been installed).

Except for the PARs on the IESO-MP interface and the IESO-MH interface, most PARs are not operated to continuously 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. The Michigan-Ontario PARs were specifically designed and constructed to provide enhanced control over inadvertent power flow between Michigan and Ontario. The equipment provides for a large number of tap positions, providing for finer granularity of control as well as the ability to adjust the tap positions hourly.

The Ramapo PARs are primarily used to facilitate the delivery of energy over the AC interconnections between PJM and the NYISO as determined by the level of economic interchange schedules of Market Participant External Transactions. 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 in accordance with protocols defined in the NYISO Market Services Tariff. The St. Lawrence PARs operate to facilitate interconnected transactions between Ontario and New York, and to make the most efficient use of the of the New York-Ontario interface capacity. These PARs are very effective at meeting their design objective. However, when system conditions change such that the design objective is not needed 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 changes 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.

A loop flow study report issues by Midwest ISO and PJM in May 2007 (http://www.jointandcommon.com/working-groups/joint-and-common/downloads/20070525-loop-flow-investigation-report.pdf) found a strong correlation between the operation of the Ramapo PARs around Lake Erie and circulation flows.

Under ideal conditions, the PARs would be operated such that they always minimize circulation flows. 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. Since the PARs are not going to always be able to minimize circulating flows and are not able to operate continuously under ideal conditions, it is important that the contributions to circulation flows be identified in the IDC. 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 potential for joint management of these flows during periods when congestion exists can be assessed.

In response to the May 2007 MISO, PJM study recommendations and to continue the advancement of regional PAR coordination efforts the following activities will be completed:

- A regional study will be initiated during 2010 to identify reliability and market impacts of the PARS or other controllable devices having a regional impact on Lake Erie loop flows. This study will also identify significant regional paths or flow gates impacted by Lake Erie loop flows.

- Upon completion of the analysis, regional operating guide recommendations may be developed and implemented by the four parties (IESO, MISO, NYISO and PJM) to reduce Lake Erie loop flow through the coordinated operation of the identified significant controllable devices. This includes implementing the necessary communication infrastructure and regional business processes to facilitate regional coordination of the identified controllable devices.

Study Steps

I. Identify the set of PARs, variable frequency transformers, series capacitors and other such devices that have the ability to alter flows around Lake Erie and should be included in the coordination process study.

II. Identify the operating characteristics of each of device:
   A. Review the historical operation of these devices and identify their expected future operation:
      1. Describe how they are operated on a daily, hourly and monthly basis and variations in the operation that are time or system conditions dependent.
      2. Describe the objectives that are trying to be met and how successful the devices are at meeting these objectives.

   B. Describe the physical characteristics associated with the operation of each device:
      1. Does the device operate in an automatic mode to meet the objectives or does it rely on manual intervention on a one-time or continuous basis?
      2. What are the equipment restrictions and the system restrictions that affect device operations?
      3. Is there a change in state from where the device is regulating to meet the objective function to where the device is not longer able to regulate (i.e. a PAR being operated at one end of a tap range)?

   C. Does an operating guide, procedure or contractual arrangement exist that defines the operation of the device? Is there any flexibility in the use of this device or other devices to meet the objective function?

   D. Market Impact of Expected PAR Schedules:
      1. Are these devices responsive to market conditions? Is their operation reflected in the market solution? Will the market solution try to adjust the device to optimize the market solution or are the devices responsive to price signals sent by the market?
      2. How are operation of these devices modeled in the day-ahead market and the real-time market? Are there market challenges associated with the operation of these devices (i.e. interface pricing)?

III. Identify how operations of the devices impact Lake Erie loop flow:
   A. Identify flowgates around Lake Erie that are impacted by each device:
      1. Is there a way to measure these impacts in both real-time and on an after-the-fact basis? Are there existing tools that can be used to measure the impact of each device or are new tools needed?
      2. Under what circumstances would this device add to or reduce loop flow?

IV. If warranted, develop a comprehensive operating guide among the four parties that coordinates the operation of the power control devices around Lake Erie:

   A. Under current operation, do these devices conflict with each other where one device is being used to offset loop flows created by another device?

B. Is there flexibility to either alter the current operation or to coordinate their operation such that the loop flow conditions can be predicted and the devices be operated to minimize of eliminate Lake Erie loop flow?
    1. Want the ability to forecast loop flows based on system conditions and expected operation of the devices.
    2. The study will recommend any special tools and/or data reporting required needed to forecast loop flows.

C. The study results will be documented in a study report of findings and the activities associated with coordinated operation of equipment will be included in an operating guide for use by the four parties.